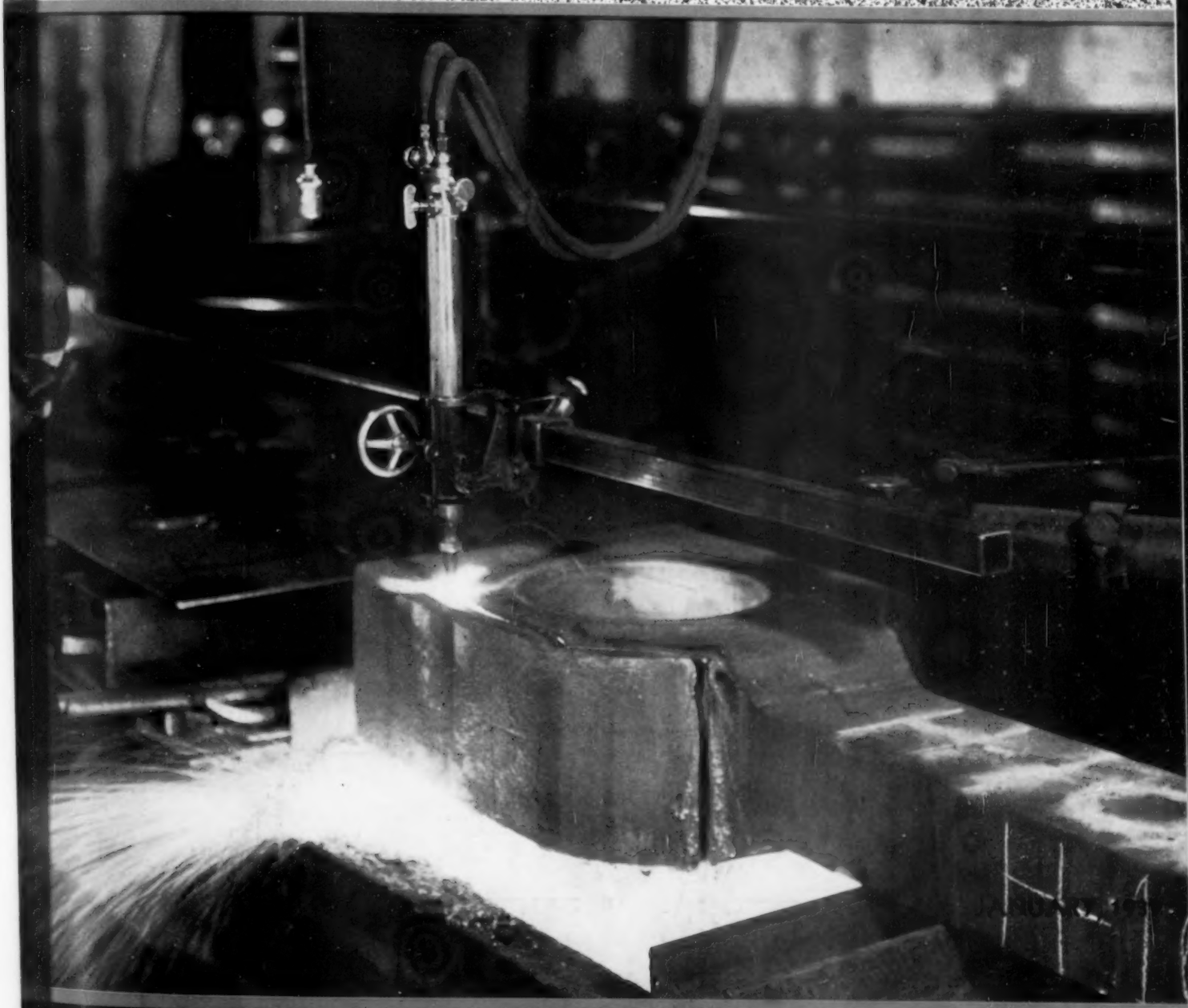
The Welding Journal



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W. SPRARAGEN, Editor

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Welding Journal

VOLUME 18, No. 1 JANUARY 1939

ARC-WELDED STEEL PLEASURE Cruisers*

By MILO BAILEY†

FOREWORD

THE subject-matter of this paper is the result of experience gained from the recent actual and successful construction of modern steel cruisers, designed for fabrication by the arc-welded method.

The principles involved apply to all pleasure craft in the cruiser subdivision from 30 to 50 feet; and on up into the yacht class.

Fabrication by arc welding is not restricted to any particular type of hull design or construction. The subject-matter herein, however, treats with the type known as the "modified" vee-bottom cruiser. Its application to the traditional round bottom type is equally successful.

While this paper sets forth the advantages of arc welding over riveted construction, its main object is to show how the application of welding brings, for the first time in history, steel craft into even competition with production built wooden cruisers.

It has long been considered by naval architects, and builders of pleasure craft, that a hull built of steel under 50 feet could not equal the speed or have the strength comparable to one built of wood.

Prior to fabrication by arc welding, the only means by which metals were joined was riveting, and the lightest shell plating (skin of the vessel) having sufficient thickness to *hold* a rivet with the required factor of safety and a tightly *caulked joint*, was $^3/_{16}$ inch.

The disproportional weight of such plating when used in a hull less than 50 feet upset its weight-displacement ratio, thus causing deeper immersion in the water and resulting in loss of speed. To this detriment is added the prohibitive cost of riveted construction, compared with current wood costs.

It is generally conceded by builders, as well as the majority of cruiser owners, that if the weight-cost problem could be solved and brought down to a competitive basis with wood, a great demand would develop for steel craft because of their greater strength, safety and low cost of maintenance.

The superiority of steel construction over wood has been proved again and again, even when riveted—but when fabricated by arc welding the product becomes evermore one to be desired.

COMPARATIVE STRENGTH OF WOOD AND STEEL HULLS

At this point it may be well to compare the strength of wooden hulls with steel, both riveted and welded, thus forming a basis upon which the full import of the advantages of arc-welded fabrication may be realized.

An analysis of the stiffness and torsional resistance of hulls, wood or steel, would be too involved and lengthy for this paper, but a simple comparison, that of tensile strength, may be easily made and readily understood from the following illustrations (Fig. 1):

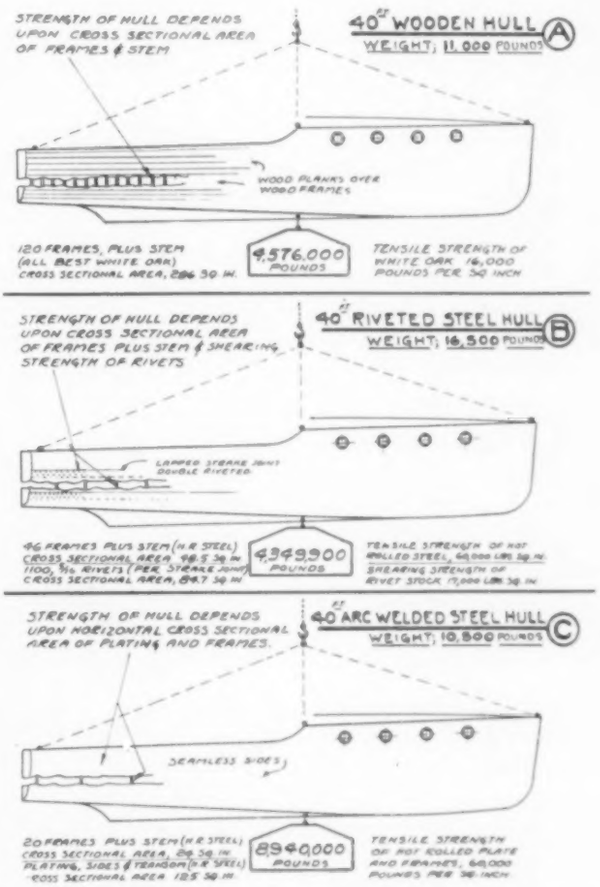

STRENGTH OF HULL DEPENDS UPON CROSS SECTIONAL AREA OF FRAMES & STEM
40' WOODEN HULL (A)
WEIGHT; 11,000 POUNDS
WOOD PLANKS OVER WOOD FRAMES
120 FRAMES, PLUS STEM (ALL BEST WHITE OAK) CROSS SECTIONAL AREA, 286 SQ. IN.
4,576,000 POUNDS
TENSILE STRENGTH OF WHITE OAK 16,000 POUNDS PER SQ. INCH
STRENGTH OF HULL DEPENDS UPON CROSS SECTIONAL AREA OF FRAMES PLUS STEM & SHEARING STRENGTH OF RIVETS
40' RIVETED STEEL HULL (B)
WEIGHT; 16,500 POUNDS
LAPPED STRAKE JOINT DOUBLE RIVETED
46 FRAMES PLUS STEM (H.R. STEEL) CROSS SECTIONAL AREA 98.5 SQ. IN. 1100, 5/8 RIVETS (PER STRAKE JOINT) CROSS SECTIONAL AREA, 84.7 SQ. IN.
4949900 POUNDS
TENSILE STRENGTH OF HOT ROLLED STEEL, 60,000 LBS. SQ. IN.
SHEARING STRENGTH OF RIVET STOCK 17,000 LBS. SQ. IN.
STRENGTH OF HULL DEPENDS UPON HORIZONTAL CROSS SECTIONAL AREA OF PLATING AND FRAMES.
40' ARC WELDED STEEL HULL (C)
WEIGHT; 10,800 POUNDS
SEAMLESS SIDES
20 FRAMES PLUS STEM (H.R. STEEL) CROSS SECTIONAL AREA, 84 SQ. IN. PLATING, SIDES & TRANSOM (H.R. STEEL) CROSS SECTIONAL AREA 125 SQ. IN.
8940000 POUNDS
TENSILE STRENGTH OF HOT ROLLED PLATE AND FRAMES, 60,000 POUNDS PER SQ. INCH

Fig. 1—Comparison of Weights of Wooden, Riveted and Welded Hulls

* Paper presented at 19th Annual Meeting, AMERICAN WELDING SOCIETY, Detroit, October 16–21, 1938. The author of this paper received the first award, in the Pleasure Craft division of the Motor craft classification, of the $200,000 Award Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio, in which savings of $1,600,000,000 were shown available to industry by wider application of arc welding.

† President and Chief Engineer, Bailey Steel Shipbuilding Co., Detroit, Michigan, U. S. A.

(*A*) A 40-foot wooden cruiser, currently produced by a recognized builder of a high-class product having extra staunch construction.

(*B*) A 40-foot steel cruiser of conventional riveted construction with $^{3}/_{16}$-inch lapped shell plating in wide strakes from stem to stern, having two rows of $^{5}/_{16}$ inch diameter rivets staggered and spaced 2 inches on any given strake joint.

(*C*) A 40-foot modern steel arc-welded cruiser having $^{1}/_{8}$ inch thickness of shell plating, with plates full width from sheer to chine and chine to keel. The lengths vary from 12 feet down to 3 feet, with only one welded joint at the chine. This joint being stronger than the plating, the hull side is considered seamless.

ANALYSIS OF COMPARISON

The surprise of this comparison lies not in the fact that the wooden hull is stronger than the riveted steel hull, but the excessive weight of shell plate necessary to adequately support riveted construction.

With the strength of hull (*A*) and (*B*) nearly even, but the weight ratio 2 to 3, it is clear then why the riveted hull could never approach the speed of a wooden hull, which eliminated it for all time as a serious competitor.

But the picture changes completely with the arc-welded steel hull (*C*). Here we find the welded hull is actually lighter than wood, has greater speed because it is lighter —and is over 90% stronger!

Short statements all—but they are facts.

If welded and riveted hulls *were* comparable in weight, there are many factors against riveted construction. First, the high cost; second, leaks at plate joints; third, rigidity of hull is only slightly better than wood.

To show how strength is increased by welding—if hull (*B*) were *welded* the strength would increase to almost three times that of the wooden hull (*A*)—a clear example of the inadequacy of riveted construction.

Although riveted steel hulls cost more and are heavier, we must nevertheless give them preference over wood; even though the strength seems low, they can stand greater impact of all kinds and harder stranding than wooden construction, and are much longer lived.

An adequately fastened riveted hull would require approximately 12,000 rivets. The punching, fitting and registering of holes must be exact in so light a plate as $^{3}/_{16}$ inch, and the more fragile the construction the more costly the fabrication must be, as it entails a great amount of bracing and accurate forming.

The cost of welded construction compared with riveted shows the great savings in welding. Further, the close expensive fitting-up of plates, punching and registering of holes required for riveted construction are entirely eliminated—a major item of cost, as will be seen.

Cost of driving 12,000 rivets	$250.00
Cost of 12,000 rivets	18.00
Cost of laying 1600 feet of $^{3}/_{16}$-inch electrode	160.00
Cost of $^{3}/_{16}$-inch electrode	21.00

From the above figures, welding cost is slightly under $^{1}/_{3}$ that of riveted construction . . . and slightly more than half for material.

It may be estimated then that in addition to the savings of welding over riveting, that only one quarter of the cost of preparing plating for riveting is required in preparing plating for welded construction.

It is clear now that riveting has no place in fabrication where maximum strength is required and costs are to be reduced in conformity with modern manufacturing methods as we know them today. Therefore, the subject of riveting as applied to the construction of a modern steel cruiser will no longer be considered.

The remainder of this paper will treat only with the progressive construction of modern arc-welded steel cruisers, and show by arc welding how steel cruisers can now more than compete with production built wooden cruisers.

ARC-WELDED STEEL CRUISERS

The question often arises, "If ships and large yachts

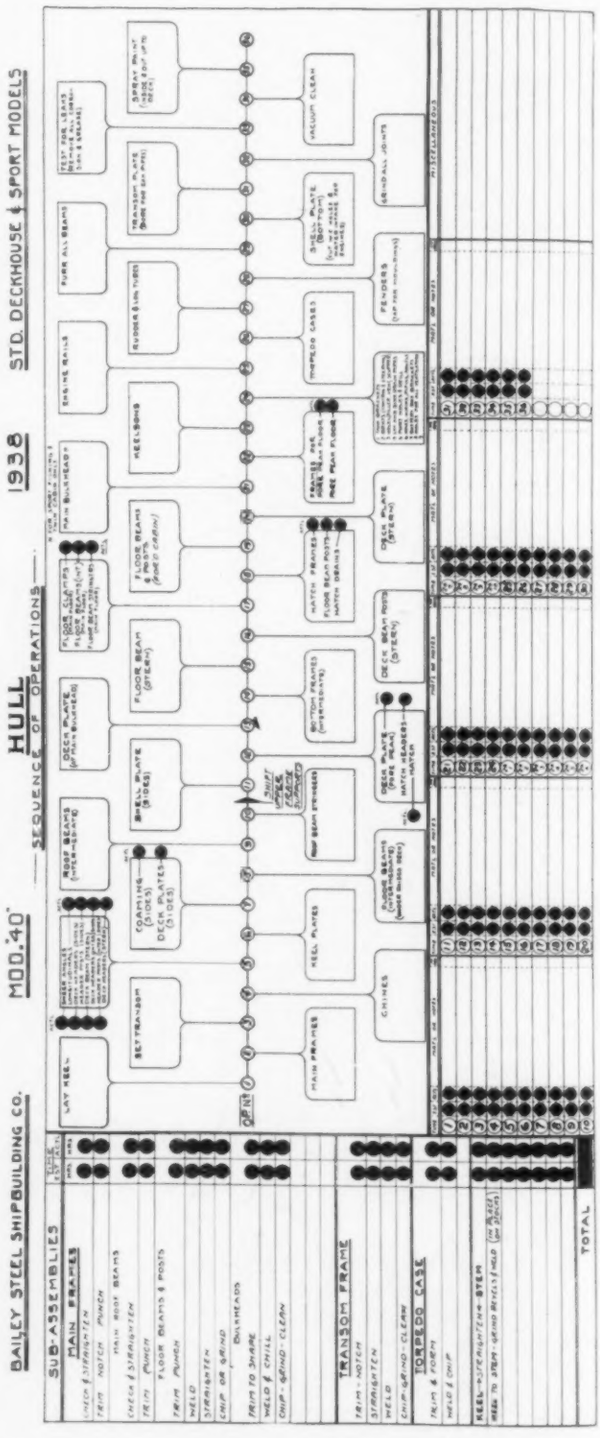


Fig. 2—Sequence of Operations

have been built of steel for over half a century, why aren't small cruisers built of steel?"

The reasons, however, are not hard to find.

First: Prohibitive cost of riveted construction.

Second: Unwillingness on part of builders of wooden craft to depart from tradition or scrap investments in wood-working machinery.

Third: Most builders fundamentally are "wood minded."

Fourth: Those who have the zeal to develop or pioneer a new idea usually are the ones unable to finance the idea through to a successful conclusion.

Fifth: Fear of the "Penalty of Leadership."

FUNDAMENTAL REQUIREMENTS FOR SUCCESSFUL FABRICATION OF ARC-WELDED STEEL CRAFT

First: It is necessary that the builder of arc-welded steel has a thorough knowledge of wooden cruiser construction, as well as the intricacies of handling, forming and welding steel; and be free from any prejudice for wood.

Second: He must be able to visualize the strength of a steel hull *after it is welded*, and carefully select the sizes of angles, channels and bars going into the construction, accordingly. His temptation will be to "go heavy" in this selection at the outset, resulting in a heavier-than-necessary hull (this is also a general failing of naval architects in designing for arc-welded construction).

Third: The fabrication of all structure must be exact—closer than that of wood—because the builder cannot remove stock to "fair" up a contour or "sweep," except by grinding, and at great cost.

Fourth: A solid, *accurate* jig must be constructed to hold all framework rigid and in perfect alignment throughout the entire construction of the hull from laying the keel to completion of the final operations of shell plating sides and bottom.

Fifth: Inaccuracies must be corrected as construction progresses, otherwise their multiplication develops into either a major problem of costly correction or poor appearance when finally finished.

Sixth: The entire procedure must be carefully analyzed and a progressive operation chart developed for sequence of operations, and rigidly adhered to.

Seventh: Select a design of hull preferably developed for arc-welded construction.

PRODUCTION METHODS AND PROCEDURE

The production methods hereinafter described were developed after several hulls were constructed and thoroughly tested, using different well-known principles of hull framing, from which the one best suited for arc-welded fabrication was to be chosen for production, consistent with strength.

The problems, welding and structural, of each type of hull were solved, and methods used to surmount any difficulties were carefully noted and analyzed, with accrued improvements carried from hull to hull.

It finally developed that a modified "Isherwood" system of longitudinal support for the shell plating provided the greatest hull strength and lightness; and aided fabrication materially.

From this background of experience and mass of data the production chart, "Sequence of Operations," (Fig. 2) was developed.

Close adherence to this sequence is absolutely necessary because it involves not only minimum of "labor" motion, but is in accordance with the welding procedure, learned from hard, expensive experience. It was found in many cases that operations and sequences had to be reversed to overcome distortion of plates or frames from heat of welding.

Operation sequence of the subassemblies such as keel, stem and main frames do not appear in the chart, as these parts are fabricated outside on contract and delivered to the line in completed units. As no special problems are involved in making these subassemblies, only short description will be made covering their construction.

The most exacting and accurate operations, those which control the varying degree of perfection of the completed hull, are tied up in operations 1 to 11.

Once safely past operation 11, only very lax supervision, poor workmanship, and bad welding can ruin the successful completion of a faultlessly fabricated hull.

FABRICATING JIG

Without the aid of an adequate jig it is almost impossible to produce an arc-welded steel cruiser that will pass the sharp inspection of a critical public.

So many dismal failures have been made attempting to equal the hull-smoothness of wooden construction, that the boating public at large believe "it cannot be done," and is usually skeptical until it sees.

All criticism centers on the buckled sheet plating caused from distortion in welding, and unevenness of line—they do not question the strength of the hull or longevity, however.

When the plating is applied to frames, the frames must be immovable and rigid throughout this operation; otherwise the plating will pull the frames out of alignment and magnify the distortion, effecting smoothness of all lines that catch the eye. How distortion in shell plating is eliminated will be described at length further on.

The jig consists of two heavy 6 x 8 inch timbers (skids) which form the base. These must be set perfectly level across and lengthwise—and parallel.

Upon the top surfaces are bolted the case beams, which are heavy steel channels, the aft faces of which must be spaced exactly the same as the hull frames—all must be perpendicular to the skids.

The "stocks" are now located on a centerline scribed across the tops of the base beams from end to end and bolted to the aft faces. The tops are notched to receive the keel and prevent lateral disalignment. Small angles are clamped to the faces and side of keel to hold keel in a vertical position until frames are welded in place.

A tie bar of angle iron is welded to the sides of the stocks for reinforcement from end to end. The lower frame supports are bolted near the ends of the base beams and are adjustable to any radial position when bolt is slacked. The upper frame supports are supported by six heavy vertical angles, the bases of which are welded to base beam extensions bolted to base beams. After operation No. 10, this whole upper structure is unbolted at the base beams and removed to the next jig to start another hull.

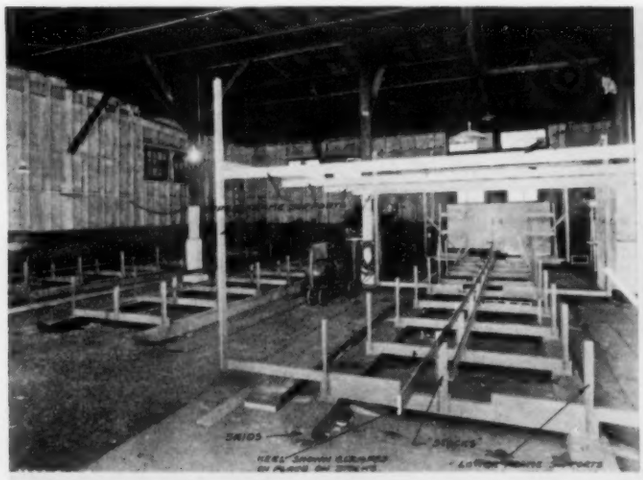
The aft faces of the upper frame supports are in perfect vertical and athwartship alignment with lower frame supports and stocks. Thus, when the hull frames are placed in position and forward faces clamped to supports, they are in perfect alignment all ways—square and plumb.

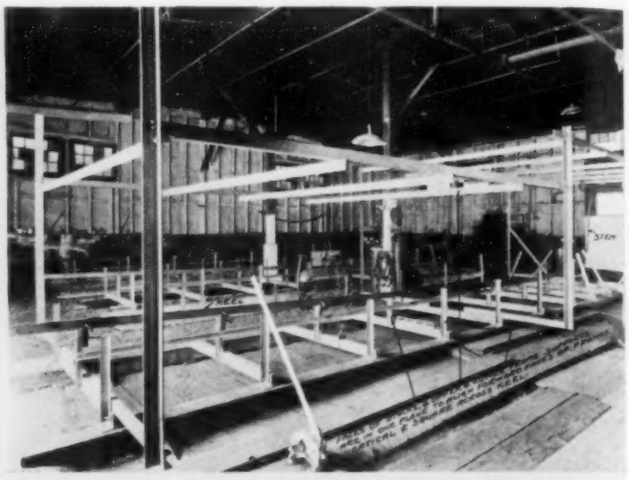
Here it may be stated that the accuracy of the entire jig is held to a plus or minus limit of $^{3}/_{64}$ inch—easily

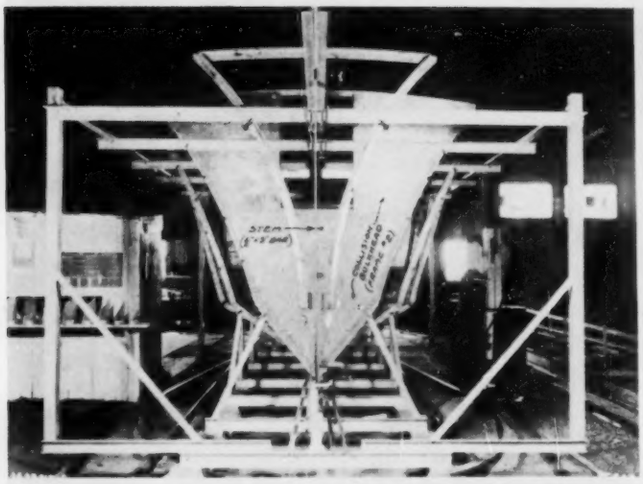
accomplished when a structure such as this is welded.

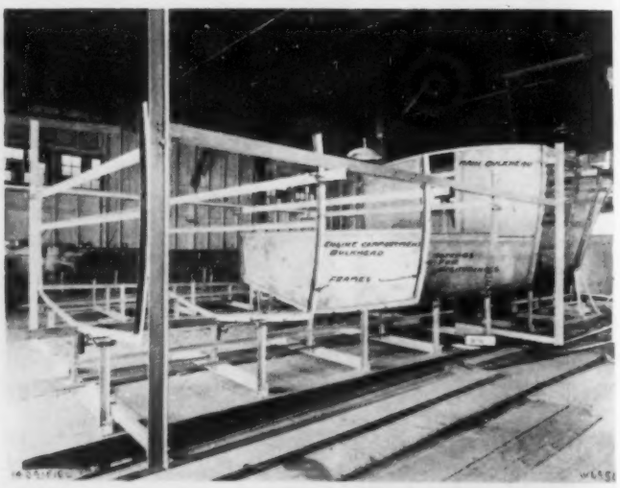
The following photographs (Figs. 3 to 8) clearly show the entire jig construction and progressive assembly of the hull. A glance back through the "sequence of operations" chart will amplify the procedure.

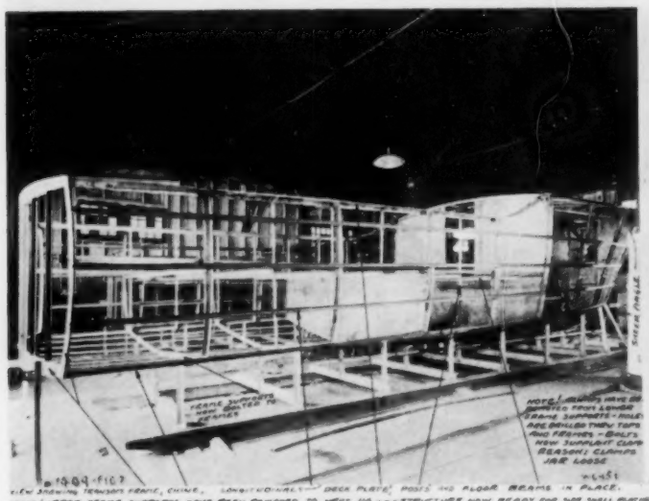
As the work progresses and the hull increases in weight, the base beams are checked frequently for levelness. This is to assure against twist of jig in case the footing under the skids settle during construction. If the skids are laid on a concrete base this will not occur.

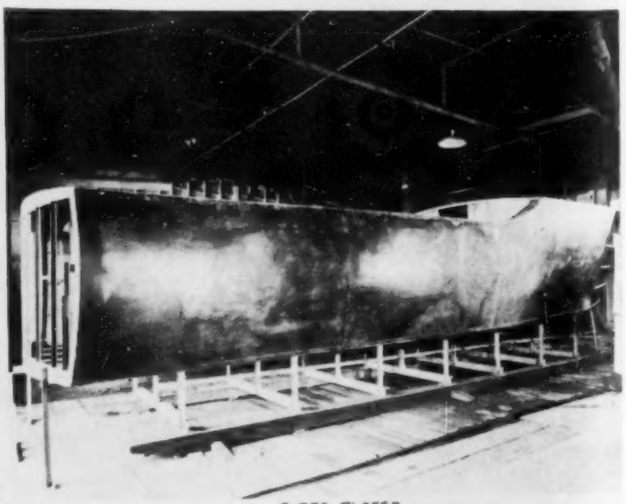









FRAME SUPPORTS HAVE BEEN CUTTED TO REMOVE FRAMES
NOTE: ALL FRAMES HAVE BEEN REMOVED FROM LOWER FRAME SUPPORTS - MALE AND DOUBLER PLATES THEN TOPS AND FRAMES - BOLTS NOW INSTALLED CLAMPS REMOVED JAB 6-6-45



Figs. 3 to 5 Figs. 6 to 8

Step by Step Procedure in the Development of a Welded Pleasure Cruiser

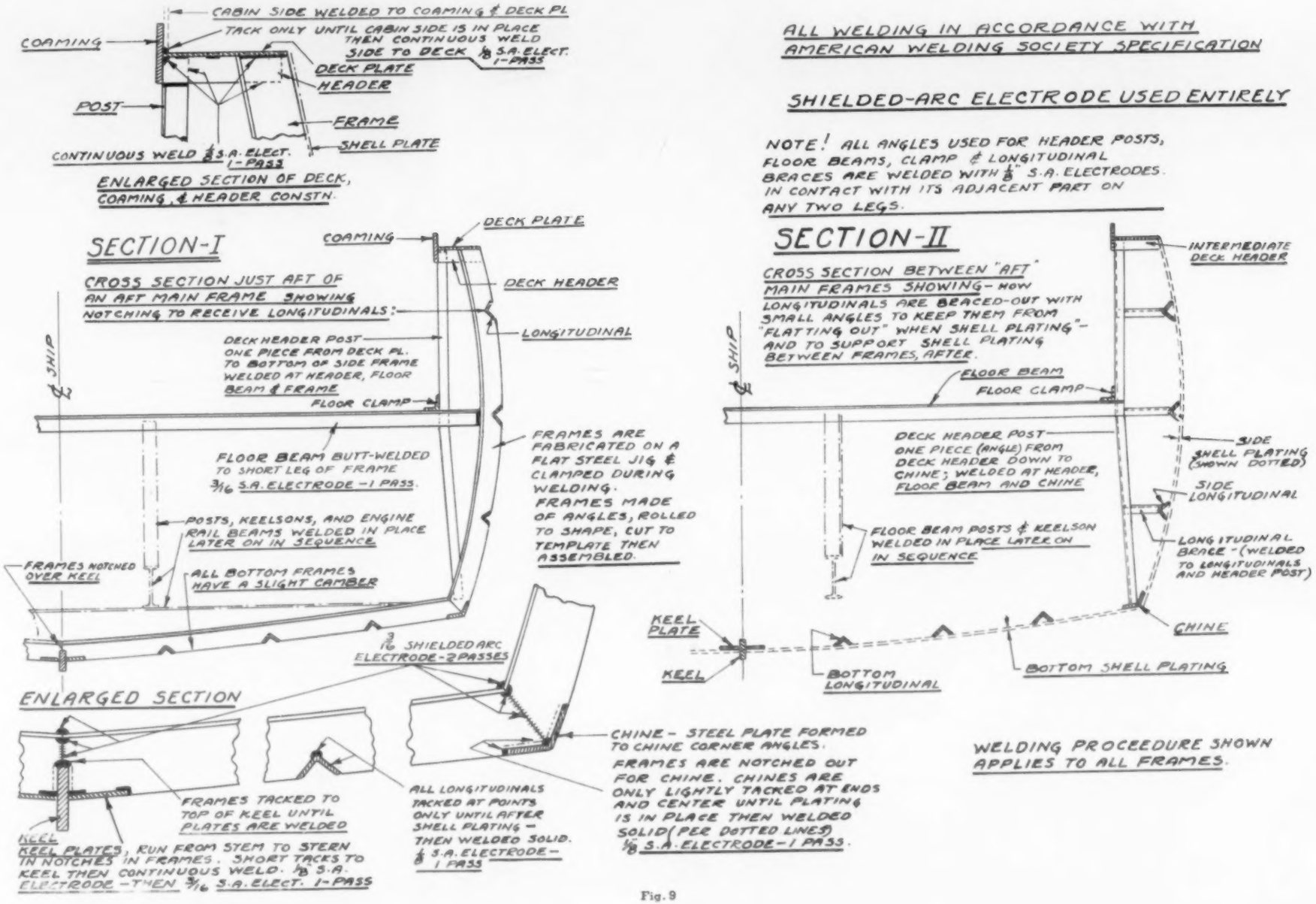

CABIN SIDE WELDED TO COAMING & DECK PL
TACK ONLY UNTIL CABIN SIDE IS IN PLACE THEN CONTINUOUS WELD SIDE TO DECK 1/8 S.A. ELECT. 1-PASS
COAMING
DECK PLATE
HEADER
POST
FRAME
SHELL PLATE
CONTINUOUS WELD 1/8 S.A. ELECT. 1-PASS
ENLARGED SECTION OF DECK, COAMING, & HEADER CONSTN.
ALL WELDING IN ACCORDANCE WITH AMERICAN WELDING SOCIETY SPECIFICATION
SHIELDED-ARC ELECTRODE USED ENTIRELY
NOTE! ALL ANGLES USED FOR HEADER POSTS, FLOOR BEAMS, CLAMP & LONGITUDINAL BRACES ARE WELDED WITH 1/4" S.A. ELECTRODES IN CONTACT WITH ITS ADJACENT PART ON ANY TWO LEGS.
SECTION-I
CROSS SECTION JUST AFT OF AN AFT MAIN FRAME SHOWING NOTCHING TO RECEIVE LONGITUDINALS:
COAMING
DECK PLATE
DECK HEADER
LONGITUDINAL
DECK HEADER POST — ONE PIECE FROM DECK PL. TO BOTTOM OF SIDE FRAME WELDED AT HEADER, FLOOR BEAM & FRAME
FLOOR CLAMP
SHIP
FLOOR BEAM BUTT-WELDED TO SHORT LEG OF FRAME 3/16 S.A. ELECTRODE - 1 PASS.
FRAMES ARE FABRICATED ON A FLAT STEEL JIG & CLAMPED DURING WELDING. FRAMES MADE OF ANGLES, ROLLED TO SHAPE, CUT TO TEMPLATE THEN ASSEMBLED.
POSTS, KEELSONS, AND ENGINE RAIL BEAMS WELDED IN PLACE LATER ON IN SEQUENCE.
FRAMES NOTCHED OVER KEEL
ALL BOTTOM FRAMES HAVE A SLIGHT CAMBER
3/16 SHIELDED ARC ELECTRODE - 2 PASSES
ENLARGED SECTION
FRAMES TACKED TO TOP OF KEEL UNTIL PLATES ARE WELDED
KEEL
KEEL PLATES, RUN FROM STEM TO STERN IN NOTCHES IN FRAMES. SHORT TACKS TO KEEL THEN CONTINUOUS WELD. 1/8 S.A. ELECTRODE - THEN 3/16 S.A. ELECT. 1-PASS
ALL LONGITUDINALS TACKED AT POINTS ONLY UNTIL AFTER SHELL PLATING - THEN WELDED SOLID. 1/8 S.A. ELECTRODE - 1 PASS
CHINE - STEEL PLATE FORMED TO CHINE CORNER ANGLES. FRAMES ARE NOTCHED OUT FOR CHINE. CHINES ARE ONLY LIGHTLY TACKED AT ENDS AND CENTER UNTIL PLATING IS IN PLACE THEN WELDED SOLID (PER DOTTED LINES) 1/8 S.A. ELECTRODE - 1 PASS.
SECTION-II
CROSS SECTION BETWEEN "AFT" MAIN FRAMES SHOWING - HOW LONGITUDINALS ARE BRACED-OUT WITH SMALL ANGLES TO KEEP THEM FROM "FLATTING OUT" WHEN SHELL PLATING - AND TO SUPPORT SHELL PLATING BETWEEN FRAMES, AFTER.
INTERMEDIATE DECK HEADER
SHIP
FLOOR BEAM
FLOOR CLAMP
DECK HEADER POST — ONE PIECE (ANGLE) FROM DECK HEADER DOWN TO CHINE; WELDED AT HEADER, FLOOR BEAM AND CHINE
SIDE SHELL PLATING (SHOWN DOTTED)
SIDE LONGITUDINAL
FLOOR BEAM POSTS & KEELSON WELDED IN PLACE LATER ON IN SEQUENCE
LONGITUDINAL BRACE - (WELDED TO LONGITUDINALS AND HEADER POST)
KEEL PLATE
KEEL
CHINE
BOTTOM LONGITUDINAL
BOTTOM SHELL PLATING
WELDING PROCEEDURE SHOWN APPLIES TO ALL FRAMES.

Fig. 9

FABRICATION

To clarify the illustrations, the new welding symbols sponsored by the AMERICAN WELDING SOCIETY will not be used. Notes will take their place.

Plate *A*, Section I, shows the detailed construction of an "aft" main frame. This assembly is made up of two side and bottom members, rolled to a predetermined arc, cut to template, and welded together in a flat steel jig (not illustrated).

The points at deck plate, chine, and keel are located to exact position by stops on the jig, holding the accuracy to $^1/_{32}$ inch. After locating these parts, they are heavily clamped with thin copper strips under the mitered joints and joint at keel. This copper plate prevents welding frame joints to the jig—also dissipates heat quickly.

To facilitate welding speed, these joints are welded only on one side, with the welding mostly downhand and at a very convenient position for the operator. After welding is completed and floor beams are welded in place, the frame is left to cool completely before removing from jig, allowing the stresses to equalize, eliminating distortion.

The next operation is mechanical—the notching out for longitudinals, chines, keel and keel plates—all done on a punch press, and accomplished in a few minutes.

The frame is now placed back on the *welding jig* to further check for distortion. Passing inspection, it is ready to be set in position on keel and clamped to the fabricating jig upper and lower frame supports. From this point the sequence of operations is followed, and SECTION I of Fig. 9 shows all members in position in cross section up to the shell plating operation No. 11.

SECTION II of Fig. 9 is a cross section through the hull midway between aft main frames—mainly showing how the longitudinals are braced between frames to eliminate any "flatting" when shell plating is welded in place, and adding considerable strength to the whole side structure.

It becomes apparent from an analysis of the design of frames and method of reinforcing that tremendous strength is built into the hull sides, actually developing into a deep girder section averaging $5^1/_2$ feet bottom to top—the full length of the vessel—and accomplished with the use of relatively light sections of metal in all component parts. Such structure, held together by arc welding becomes tremendously rigid—in which hull strains resulting from violent action in the water *do not localize* in any particular section, but are distributed over great areas.

Contrast this with wooden hulls where all strains localize at the fastenings, which become loose allowing planking and framing to weave and open up. This is one reason why wooden hulls have only half the life of steel.

SHELL PLATING

Shell plating—the stumbling-block in successful construction of all light-weight welded craft.

Careful analysis of failures indicate the following reasons:

1. Steel sheets having hard and soft areas, locked-up rolling stresses, and waves.
2. Forcing sheets to conform to frame curves, thus setting up stresses which are released by welding heat into uneven "breaks" and irregular surfaces.
3. Weak framing, poorly supported.
4. Frames or longitudinals *not* "fair." ("Fair," is the evenness of continuous curves from bow to stern, or sheer to keel at any section of the hull surface.)
5. Poorly controlled welding heat, size and quality of electrode used.
6. Excessive welding speed and inadequate time allowance for cooling.
7. Lack on operator's part of good welding sense and good judgment of heat adjustment.
8. Inadequate means of holding plating to frames during welding operation.

Assuming all the adverse conditions above have been overcome, the procedure for successful shell plating is illustrated and described as follows:

Figure 10 is an outboard profile of hull indicating sizes of sheets used, welding procedure and details.

The first operation in plating is to make templates of light wooden strips nailed and glued together, the outside edges of which are even with the deck plate line, forward and after edge of plate (whatever length decided upon), and the chine corner, or lower edge. This gives the developed shape of the plate, and when flattened out on the blank sheet the edges become the line to which the sheet is trimmed. This trimming is done by a new type of portable electric shear which trims to any contour at the rate of 6 feet per minute, $^1/_8$-inch plate maximum capacity.

All plates are now rolled to the approximate curve of the frames they cover. Preliminary rolling, no matter how *slight*, is necessary to smooth plating, because the stresses then have assumed the characteristic of the frame curve and remain static with no tendency to "release" in other direction when heat of welding extends its area and upsets the molecular structure of the steel.

The plates are now "hung" from the tops at the deck plate edge by "C" clamps, then shaped "strong backs" (angles bent to a slightly greater radius than the frame contour) are clamped over the plating and held at tops also by "C" clamps. The "strong backs," spaced about a foot apart, are brought down tightly over the plates, thus bringing plates into contact with the frames and longitudinals tightly, then they are clamped to the chine.

By hanging plates from tops and "ironing out" toward the chines, advantage is taken of gravity to hold the plate close (plates weigh from 200 to 350 pounds each) and overcome friction from plates creeping on frames or longitudinals.

Plates are now ready for welding to structure and, progressively as noted on Fig. 10.

WATER COOLING

During the entire welding operation, those of welding plate to longitudinals and frames (but not deck plate or chine) the plates are cooled with a fine spray of water near the vicinity of the weld—restricting expansion and shrinkage to a small area around the weld, and stopping heat penetration before it can cause distortion of plates in the unsupported areas. Tests have been made chilling the weld while still cherry red with no tendency to crystallize or reduce strength of either the weld or plate. Water cooling, therefore, is safe and aids materially in eliminating buckles. The continuous weld at chines and deck plates are cooled more slowly as the thickness of metals here vary and a quick quench causes plating to shrink faster than the chine or deck plate.

Welding the plate-to-plate joints has always been a source of trouble. Various gaps were tried with varying degrees of success. The particular difficulty lies in the expansion of the two edges toward one another to the ex-

8 FT. SHEET FULL WIDTH
12 FT. SHEET - FULL WIDTH
12 FT. MADE UP OF 4 SHEETS FORMED TO SHAPE ON POWER HAMMER
DOTTED LINES INDICATE MAIN FRAMES
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PLATE TO PLATE JOINT
TRANSOM PLATE FULL WIDTH OF STERN - 1 PIECE
DECK PLATE
HEAVY ANGLE CLAMPED TO TOP OF DECK PL. TO HOLD PLATE FLAT WHEN WELDING
TACK WELD ENTIRE LENGTH INSIDE (1/8 ELECTRODE) THEN CONTINUOUS ON OUTSIDE CORNER - 5/32 ELECTRODE 1-PASS.
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BOTTOM LONGITUDINAL
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KEEL PLATE
TACK PLATING TO KEEL (1/8 ELECTRODE) FINISH WELD CONTINUOUS (1/8 ELECTRODE) PEAN.
TACK PLATING TO KEEL PLATE (1/8 ELECTRODE) FINISH WELD CONTINUOUS (1/8 ELECTRODE) 1-PASS (PEAN CAREFULLY)
KEEL

Fig. 10

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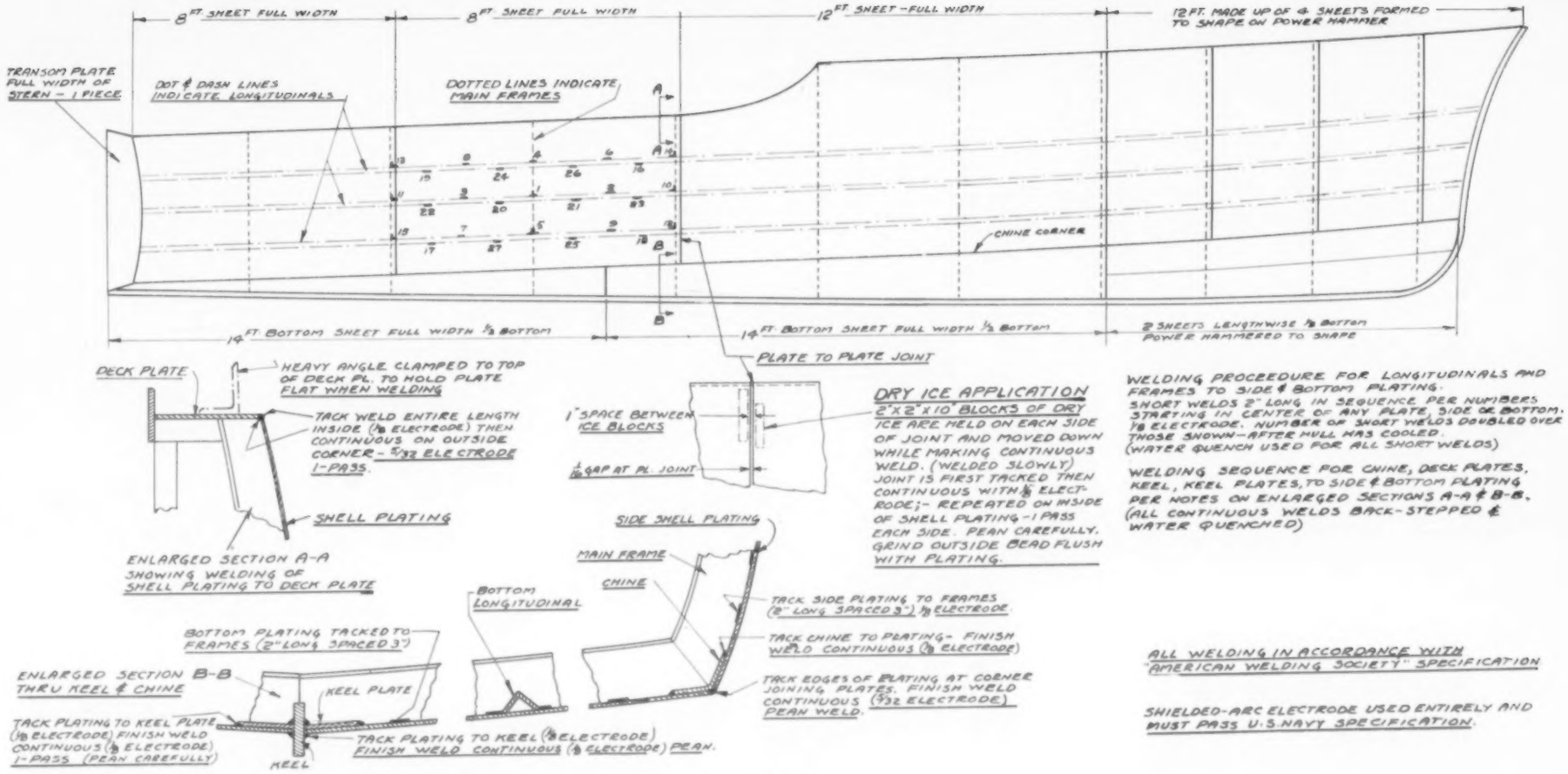
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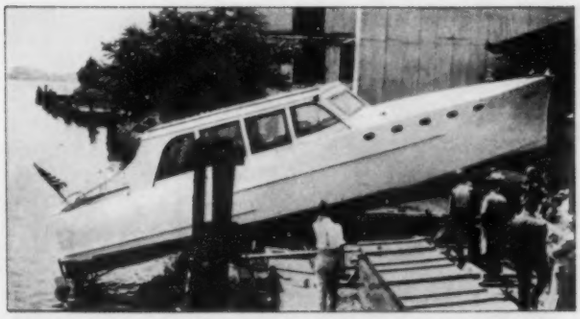
Fig. 10

ROOMY FORWARD STATEROOM

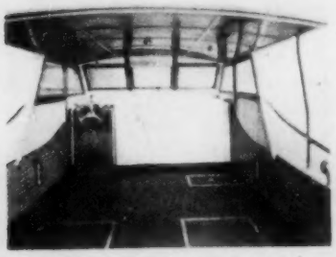


SUPER-STRENGTH! SUPPORTED ON 8" OF KEEL WITHOUT DAMAGE OR BENDING

A CLEAN RUNNING HULL

SPECIAL SPORT FISHING CRUISER

LARGE CLEAN GALLEYS



COCKPIT OF SPORT FISHING CRUISER

STREAMLINED DIESEL 48 FOOTER

Fig. 11—Views of Welded Pleasure Cruisers

tent of causing an in-or-out buckle full width of the shell plate.

TO PREVENT THIS, *DRY ICE* WAS USED.

We had never heard of its application to welding problems before, and since, have found no one using it. (The Dry Ice Company, subsidiary of the Air Reduction Company, informs us that to their knowledge it has never been used before, and have taken considerable interest in this application).

The theory of application was—if the heat of the weld on the edge of each plate at the joint *could be restricted to a very narrow margin on each side of the weld*, then the amount of expansion of each plate toward the other would be reduced to within the limits of the narrowness of the margin; therefore, reducing the in-and-out buckle to a minimum. Placing cakes of dry ice on both sides of the weld with the closest clearance possible consistent with the operator's skill restricted this area down to within one inch total—*and solved the problem.*

The dry ice absorbed the heat so fast there was no spreading of heat beyond the margin; therefore, minimum of expansion.

The application of dry ice to the welding of bulkheads to frames was used with great success, as all sheets were perfectly flat when finished.

It may be argued that it is no problem to weld a flat sheet to structural iron and keep it flat and free from buckles, true in heavier plate $^3/_{16}$ inch and up, but try one with No. 12 gage, 10 feet long by 6 feet wide, continuously welded all around—gas tight and have it pass navy inspection for flatness without the use of dry ice!

BOTTOM PLATING

Bottom plating does not present the difficulties encountered in side plating, as it has very slight convexity and practically no forming—except at the bow end where it is power-hammered to templates.

These plates are developed and trimmed the same as the side plates, and held in position against the bottom frames and longitudinals by several straight heavy angle irons running fore and aft. The welding procedure is identical with the sides.

TESTING FOR WATERTIGHTNESS

After all shell plating, sides and bottom (also transom plate) have been "welded-off," all welds are smoothed up by grinding. Carbon-tetrachloride is then flowed on all joints to test for leaks—any found are promptly closed by welding, re-ground and tested again. Much credit can be given this method of testing, because carbon-tetrachloride can penetrate the most minute opening. Suffice it to say no hull so far has ever leaked a drop that has passed this test!

The main problems encountered in fabricating arc-welded steel cruiser hulls have been set forth—and the method of their solution, from practical experience, described. Therefore, as there are no remaining problems involved in the finishing of the cruiser, description will here be concluded.

COMPARATIVE COST OF WOODEN AND ARC-WELDED STEEL CRUISERS

Costs of welded steel cruisers compared with wooden cruisers are about equal when a low quantity in steel exists—but in quantities equalling large production, the cost of welded steel cruisers will be less by 14%. (The writer manufactured wooden cruisers for several years before producing in steel—and substantiating data on costs are on file.)

INCREASED SERVICE LIFE, EFFICIENCY, GENERAL ECONOMY AND SOCIAL ADVANTAGE PROVIDED TO MANKIND THROUGH THE USE OF A MODERN ARC-WELDED STEEL CRUISER

A welded steel hull is no heavier than a soundly constructed wooden hull of the same size, even when the wooden hull is new. And, of course, a steel hull does not soak up water and become heavier with age as a wooden hull does. Consequently, a steel boat remains the same weight throughout its entire life.

The normal life of a steel hull is twice that of a wooden hull for it is not subject to the rot or to attack from marine borers. It never requires calking or replacing of planks, and of course, is far stronger.

A welded steel hull is more easily repaired than a wooden one. It requires only cold bumping, and in case of a through fracture, welding, whereas, if planks are smashed in a wooden hull it becomes a long drawn-out expensive operation, and, there are a thousand metal workers to one experienced boat builder who knows how to replace a plank. Most any small town garage has a "metal man," but you won't find a "planker" in every out-of-the-way place.

Today new corrosion resisting steel alloys, rust preventatives, new finishes and new methods of steel treatment produce corrosion proof hulls. New insulation and air conditioning principles eliminate "sweating" or condensation on the inside of a hull. In a properly constructed modern steel cruiser, the bilges are so dry they are actually dusty.

Compare this with the wooden cruiser which must be calked, have rotten or broken planks replaced, have its fastenings tightened, and must have constantly pumped out, the slimy water of an always submerged and more or less leaky bilge.

A cruiser built of steel is safer, cooler, is always dry inside, retains its shape, can be frozen in without harm, and is more sanitary.

When you step into a steel cruiser you immediately sense a feeling of greater stability. Subconsciously you know that water-tightness is assured because there are no seams to leak or open up in a blow. You notice "liner" technique of construction, steel bulkheads that can't fail, that the engine compartment is welded to air tightness from the main portion of the hull, an item assuring fire proofness—and most important of all, that here is a ship which, because of its natural strength of construction, can stand a battering that no wooden one could take.

Finally, such a boat costs no more to buy in the first place than a well-built wooden boat, and the lower upkeep cost and longer life make it far less expensive to own in the long run.

Summed up, the advantages of steel construction are:

All-welded steel hull and superstructure—no leaks.
Maintenance cost is $^1/_4$ that of wood.
Cabin sides cannot crack or open up.
Hull can be frozen in without harm.
Complete insulation against heat, noise and vibration.
Cooler in the Tropics.
Immune to marine borers (Toredo).
Quieter and Smoother.
Dusty-dry, odorless bilges.
No wet rot or dry rot—no caulking.
Built for use in any waters.
Engines in stern, enclosed in fireproof steel compartment.

Fig. 1—Photograph of the U. S. Coast Guard Cutter ESCANABA Which Is One of the Three Identical Same Vessels Constructed by Our Company. These Vessels Were Not All Welded but in the Construction a Large Amount of Welding Was Used. These Vessels Were 165 Ft. in Length, 36-Ft. Beam, Powered by 1500-Hp. Geared Turbine, Steam Being Furnished by Two Water Tube, Oil Fired Boilers with 340-Lb. Gage Pressure and 200° Super-Heat

Fig. 2—A Detroit River Mail Boat, O. F. MOOK, Which Distributes the Mail to All Vessels Passing Detroit While Under Way the Mail Being Delivered in the Middle of the River. This Being Known as the U. S Marine Post Office. This Boat Is All Welded, 68 Ft. Long, 14-Ft. Beam, and Powered by a 165-Hp. Diesel Engine Operating Through Reduction Gears

WELDING IN THE CONSTRUCTION of Large Steel Yachts, and Medium Size Commercial and Government Vessels*

By W. E. WHITEHOUSE†

FROM the subject of this paper the question naturally arises: what has welding done for the construction of large steel yachts and medium size commercial and government vessels? In this paper, I will not deal with the technicalities of design or fabrication entering into this form of construction, but will discuss rather the economies and advantages to be gained with a brief outline here and there of some of the problems.

First, a problem: the problem of personnel. This is a case of developing the right men from the draftsmen to the welders. I say developing as very rarely can you just go out and find such men. Too often not only draftsmen, foremen and workmen but even the engineers have been trained in the old school of riveting so long that the possibilities of the elimination of excess weight and needless labor are overlooked with a resultant cost greater than necessary. The burden thrown upon the designing engineer was never greater than now, but on the other hand never has there been such an opportunity for true original ingenuity to show itself. The old riveted form of construction is bound by hide bound rules of the government, American Bureau of Shipping and Lloyd's. Not so the welded hull. There are a number of rules, yes, but these are mainly general covering strengths to be maintained and the qualification of welders. The engineer now can really show originality. As stated above, this means more work, longer hours, and more intensive study on the part of the engineer, but when you consider what is to be gained it is worth it.

Right here I might cite an example of the above. The shipyard which I represent has under construction two U. S. Coast Guard Harbor Cutters, each 110 feet in length, diesel electric propulsion, all welded. The Bureau of Construction and Repair of the U. S. Coast Guard is one of the most progressive of all Government Bureaus, and they have lately requested of us that we, cooperating with them, develop entirely new details in the making of entirely all-welded deck and hull fittings, such as quadrant, bitts, chocks, scuppers, pads, etc., and forget the usual cast or partially cast type. We, of course, are delighted as it gives us a chance to use our own initiative and save money, yet assuring the government a better job.

Welding lends itself readily to the construction of vessels of the type covered by this paper. I will cover a few of the details later in conjunction with a brief discussion of particular points of interest in a few distinctive vessels. I would like to say now, however, that my company is averse to building any more riveted vessels. We hope we never have another riveted job, even though it means a considerable portion of our yard equipment is not used. Devising new processes and new methods which will produce a better product at a lower cost is far more appealing to a good workman than running along in the same old rut.

The question naturally arises in the average man as to where the economy lies. First, by eliminating all riveting flanges of shapes, all clips, all plate laps, all rivet heads, all seam and butt straps, all bosom straps, all bulkhead bounding bars, in practically every case all reverse frames, etc., a very material saving in weight of steel is obtained. Second, many labor operations are omitted or reduced, such as punching, reaming, countersinking, a large portion of the drilling, riveting, caulking, a large portion of the mold loft work, testing is reduced to a minimum, fitting is much less owing to

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† Assistant Manager, Defoe Boat & Motor Works, Bay City, Michigan.

omission of rivet holes, pattern work is greatly reduced, etc., all being replaced simply by the welders.

I must point out here, however, that another problem develops which must be met. These vessels of the type we build are all shaped; that is, they have no dead flat on bottom or sides as is the case in large ships. This means that practically every plate in the shell has a double set or dish shape. Plates to be riveted have the rivet holes in which bolts are used to pull the plate into shape against the adjoining structure steel to steel. Very often a plate having a double set and to be riveted can be rolled one way and pulled with the bolts to put in the set the other way. Not so with plates to be welded. These plates must be bumped to shape so the plate fits the hull neatly prior to welding. There are no holes for bolts. But this again offers the engineer and plant superintendent and foremen an opportunity to use their heads and develop means to accomplish the job at the lowest possible cost, and the cost of this apparently difficult erecting operation is much more than offset by the saving outlined previously.

To be more specific in this discussion I would like to refer to definite vessels which my company has built, pointing out the particular phases of the welded construction I believe would be of interest to you.

First, the subject of government vessels. As previously stated we now are building two all-welded cutters for the U. S. Coast Guard. These vessels are now in the process of erection and we have no definite data now which I believe would be of particular interest. I can only say that all of the welding is being done in accordance with Appendix 5 of the U. S. Navy Specifications, all electrodes used being on the Navy approved list, and all welders must pass the latest Navy qualification test. Without doubt as this job progresses, much valuable experience will be gained and useful data collected. This second cutter, which we call our Hull 164, is the thirty-third vessel which we have built for the U. S. Coast Guard in the last fourteen years: so, knowing this department as we do and with the cooperative work of their bureaus, I have no doubt a product will develop adding much to our knowledge of welded procedure in vessels of this class.

A few years ago we built three steam turbo-gear cutters for the U. S. Coast Guard which, although largely riveted, had a large amount of welding in the construction.

Figure 1 is a photograph of the Cutter ESCANABA, the other two vessels being sister ships.

For one thing the entire hull forward and the water line belt is plated $^{7}/_{8}$ inch, lapped. The $^{7}/_{8}$ inch thickness at the lap, top and bottom, is filled with a full-welded fillet full length to eliminate any sharp edge to catch on the ice. A great deal of the interior structure is also welded.

Right here I am going to tell a story on myself, how I made a bad error and how welding saved my skin. Note the four pair of special boat davits. In making up our estimate for our bid on the first vessel, I used a quotation received of so many dollars a set for the special davits erroneously putting into our estimate this figure as being the total required. It later developed, after we received the contract, that a set was a pair and we were just out the cost of the other three pair and these davits were very costly, being almost entirely of cast steel. After due deliberation we submitted to the Coast Guard the proposition of our making these davits all welded of structural material. They approved same and on completion we found that our cost for all four pair was about the same as the quoted price on one pair and a better davit, lighter and stronger, had been produced. The Coast Guard were so well pleased with this type that when specifying the davits for their 328-ft. Cutters, built in the Navy Yards at Philadelphia, Brooklyn and Charleston, this same type of davit was called for. We received the contract from the Navy and built all fifty-six of these all-welded davits for these vessels. "Necessity is certainly the mother of invention."

Enough for the Government and we will pass on to commercial craft. Figure 2 is the mail boat O. F. MOOK built for a very special service in record time and all welded. Here in the Detroit River is a marine post office, the only one in the world. The mail is delivered aboard the ships passing through the Detroit River while underway. They never stop. The boat shown in this picture is in reality simply a floating post office, with sorting room, etc., delivering the mail to each ship as it passes Detroit.

The mail contract changed hands a few years ago and the man securing the contract was without a boat. His contract, awarded early in April, called for his having a suitable boat in commission the first of July. We received the job to build the boat and were just seven weeks completing same from the time we were notified to proceed and complete. The boat passed the postal authorities specifications and inspection and was doing business on July 1st. Without welding this would not have been possible.

Figure 3 is a picture of another very special vessel, the City of Chicago Fireboat FRED A. BUSSE we built a year ago all welded to the highest classification of the American Bureau of Shipping. Here again without welding this vessel would never have been built. The original specifications called for a riveted construction and the bids on this basis were above the appropriation and rejected. We later offered to build the boat for Chicago, all welded and having the specified classifica-

Figs. 3 and 4—The City of Chicago Fire Boat FRED A. BUSSE. This Vessel Is 92 Ft. in Length, 22-Ft. Beam, There Being Installed Five Diesel-Engines of 250 Hp. Each or a Total of 1250 Hp. One-Engine Is Used for Propulsion Only; Two of the Other Four Engines Are Used for Either Propulsion or Pumping with a Clutch at Both Ends, While the Remaining Engines Are Used for Pumping Only. There Are Four Pumps, Two Stage, 10-Inch Centrifugal. This Boat Has a Water Pump Capacity Through the Deck Outlets of 12,500 Gallons of Water per Minute at a 110-Lb. Pressure, 10,000 Gallons of Water per Minute at 150-Lb. Pressure, and 5000 Gallons of Water per Minute at 320-Lb. Pressure. This Vessel Is All Welded and Built to the Highest Classification of the American Bureau of Shipping

Fig. 5—An All-Welded Tug Boat, THOMAS E. MORAN, Which Is One of Two Tug Boats Just Completed and Delivered. These Vessels Are Built to the Highest Classification of the American Bureau of Shipping. They Are All Welded and Are the Very Latest Development in Diesel Electric Propulsion. There Are Installed Two 8-Cylinder Generating Engines of 750 Hp. Apiece, Furnishing Current to Two 500 Hp., 1200 R. P. M. Electric Propelling Motors Operating Through a Single Reduction Gear Box to a Single Screw. These Vessels Are 94 Ft. in Length and 26-Ft. Beam with a Registered Gross Tonnage of 158

tion and pumping requirement at a price within the appropriation if we could follow our welded structure. Chicago accepted our proposal, the vessel was built, and the pumping capacity exceeded the specification by 28.4 per cent. The vessel has been most satisfactory and widely publicized. Not only was the hull all welded but all fire piping as well. The fire lines were ten-inch pipe with special welding fittings. This welding materially aided the water flow, allowing a very small pressure drop (actually but 18 pounds between pump and turret nozzle at 150 pounds pump pressure, 15 lb. of which was in the turrent or a net drop in the pipe line of but 3 pounds).

Figure 4 is interesting from the standpoint of throwing water although the boat is hardly visible. This is a stream from a 3-inch nozzle with a pump pressure of 320 pounds. This stream was thrown about 500 feet. The low-pressure drop from a welded line was a big factor in making such a stream possible.

Now for the real work boat. Figure 5 shows one of the two tugboats my company has just completed for service in New York Harbor, the New York State Barge Canal, the Great Lakes and Coastwise. These vessels are Diesel electric propelled and are all welded to the highest classification of the American Bureau of Shipping. One thousand shaft horsepower is derived from General Electric motors operating through a single gear box obtaining current from two General Motors two-cycle Diesel engine generating units. This is another instance of the economies to be obtained from an all-welded construction making the building of these vessels possible. Commercially, of course, the investment in such a tow boat must pay dividends and such investment must not exceed the point where the vessel will earn. The saving in a steel structure all welded with new methods results in this decreased investment. Also there is no question in our minds but what the all-welded hull is stronger.

Now let me show the type of vessel which all men with sporting blood dream about. The fine pleasure yacht. In the building of yachts welding is particularly adaptable. As we all know every yachtsman wants all the speed he can get and speed is dependent on weight. The saving in weight in an all-welded yacht is a material factor in her success.

A yacht also must, of course, have beauty and be pleasing to the eye. Bumped shapes butt welded allow compound curves with what is commonly termed a stream-line form. The hull itself can readily be butt welded showing a perfectly smooth side with no laps or sight edges. In the old riveted form of construction seam straps were required which were always costly to install and a nuisance to maintain.

Permit me to show an example (Fig. 6) of a modern yacht we built this last year.

This yacht was built for an Eastern yachtsman, to the highest classification of the American Bureau of Shipping, he desiring all the beauty and comfort possible at an expenditure commeasurate with the trying financial times this country has been passing through. As we all know building costs are higher now than in 1929, if old methods are followed. Again as we all know, now, to sell a product we must offer a better article at a lower price, and the only way to solve this problem with higher labor costs is to develop new methods. Welding is one answer. There are, of course, others, but welding is a major factor in the solution. The yacht shown in this picture could never have been built within the owner's budget without welding. I think you will agree with me that the owner's requirement as to beauty was fulfilled and I can assure you the requirement of comfort was also.

And now to conclude, let me show you one more photograph (Fig. 7). This yacht takes advantage of every phase of welding. The hull is of steel, all metal arc welded, and the superstructure is of the 52S and 53S alloy of aluminum gas welded. This yacht, 115 feet in length with all comfort for the owner and his guests, air conditioned, acoustically treated, etc., weighs but 92 tons, while a yacht of the conventional riveted type of construction and under the old methods would weigh about 125 tons. The result is a lower construction cost, a better and more comfortable vessel with a resultant increase in speed of about 4 miles per hour with the same horsepower. Future yachts must follow new methods, new adaptations, and progressive engineering to have an appeal to the modern yachtsman.

Fig. 6—This Yacht Is All Welded, No Rivets Being Used Whatever in the Construction. This Vessel Is 150 Ft. in Length and 24 Ft. 6 In. Beam, Powered with Two 800-Hp. General Motors Diesel Engines Operating Twin Screws Through Reduction Gears

Fig. 7—An Ultra-Modern Yacht Now Just About Complete. This Yacht Is of All Metal, Steel and Aluminum, Is All Welded, All Compound Curves Being Bumped to Shape. This Vessel Is 115 Ft. in Length and 17 Ft. 6 In. Beam, Being Powered with Two General Motors Diesel Engines of 225 Hp. Each.

SINGLE-PASS ELECTRIC WELDING of Unfired Pressure Vessels*

By ROBERT M. WALLACE†

THE introduction of the single-pass method of electric welding, commonly known as "Unionmelt," and developed by The Linde Air Products Co., has given the fabricators of welded products a new tool with which to improve the quality of their output as well as to lower their production costs. There is every reason why welding for vessels built in accordance with the A. S. M. E. and A. P. I.-A. S. M. E. Unfired Pressure Vessel Codes should be of the highest quality, therefore this new single-pass method of welding, employing high current, has definitely taken its place in producing quality welded pressure vessels.

In the welding department of The Griscom-Russell Co. plant located at Massillon, Ohio, there has been in operation for over a year an automatic single-pass welding machine which has produced hundreds of pressure vessels for all types of service. Most of the work has been subject to inspection by Code rules. Much experimental work was done prior to its application to production, as it was necessary to process the work slightly different than in the past in order to best satisfy the requirements of the machine. It is true of any automatic operation that the work must be properly prepared if the result is to be a quality product.

The "Unionmelt" welding process employs an automatic welding head for feeding a bare rod and controlling the electrical characteristics of the rod, and makes use of a mineral composition, hereafter referred to as Melt, for protecting the molten weld metal. The Melt surrounds the electrode and completely fills the groove prepared for welding. In its fused state, this mineral composition has a resistance to the current to such a degree as to supply heat for welding, as well as providing a complete liquid puddle for protection of the deposited metal from contamination, and which upon solidification, remains on the weld until cooled. This scale is easily removed or falls off in cooling. As shown later there is almost a complete absence of nitrogen in the deposited weld-metal.

The welding head is supported on an overhead crane which travels on a built-up structure. Thus, longitudinal seams are produced by traveling the head while the work remains stationary. Girth seams of cylindrical shells are made by rotating the work by means of motor driven support rolls. All operations of the automatic head as well as all motions of the crane and work are controlled from one central station directly where the welding is being performed.

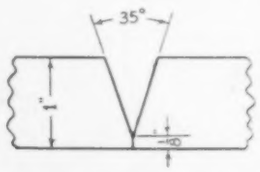

Fig. 1—Plate Edge Preparation—1 Inch Thick for Copper Back-Up

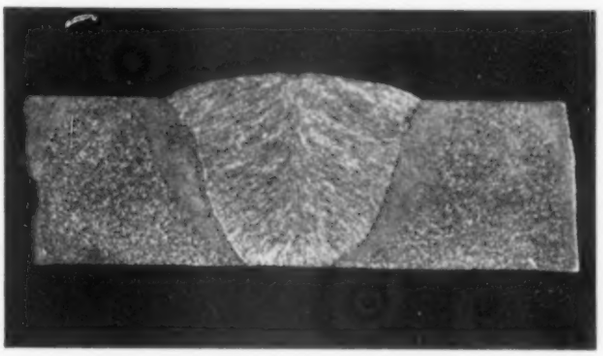

Fig. 2

Inasmuch as all the welding is done in one pass by this process, it is necessary to have all seams properly backed up. This is accomplished by using a copper bar for longitudinal seams and a copper ring for girth seams.

It is necessary that this backing up bar fit the bottom surface adjacent to the edges of the abutting plates with sufficient tightness to prevent the molten weld metal from running out. The copper bar is held in place by means of air cylinders which exert a force equal to 20 lb./sq. in. on the shell contact surface of the bar. The copper ring is supported in place by means of a disk placed under spring tension. The ring, being smaller in diameter than the inside of the shell, is free to rotate as the work is revolved. One size of ring will take care of cylindrical shells varying in diameter as much as 6 inches to 10 inches.

Facilities for providing proper backing up for both longitudinal and girth seams are now in use for vessels ranging from 14 inches in diameter up to 84 inches in diameter. Where the thickness of the plate is excessive in relationship to the diameter of the vessel, the fused melt and weld metal rolls downhill and a limit is reached for girth seam work. In order to take full advantage of this process of welding in such cases, a continuous manual back-weld is deposited part way through the thickness of the plate, and the balance is automatically welded by machine. It is not necessary that the abutting edges of the plate be chipped after manually back-welding prior to making this automatic weld. This same method of manual back-up is employed where it is impossible to reach with satisfactory mechanical copper backing up bars, as in the case of welding a dished head on both ends of a cylinder.

Since this method of welding produces complete penetration in one pass, no welding on the under side of a butt joint is required; however an extra bead applied by a

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† Assistant Superintendent, The Griscom-Russell Co., Massillon, Ohio.

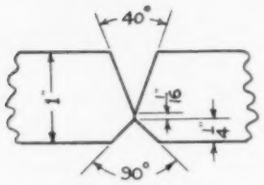


Fig. 3—Plate Edge Preparation—1 Inch Thick for Manual Back Weld

manual process may be satisfactorily made to provide extra reinforcement if desired. In such cases, the underside of the automatic weld should be cleaned so as to permit complete penetration of the welding applied on the underside.

Figure 1 shows the type of plate preparation for 1 inch thick material. The bottom side of the plate is ground with an emery wheel to remove all mill scale. Figure 2 shows an etched cross-section view of a 1-inch plate weld in the as-welded condition. The molten metal which runs through the bottom is termed "flash," and is removed by grinding when X-ray examination of the seam is required. Note the smooth even reinforcement on top, there being no undercut of the weld into the plate. The height of this reinforcement can be controlled by varying the welding conditions.

Figure 3 illustrates the proper plate edge preparation for 1-inch thick plate where a manual back-weld is employed. Figure 4 is an etched cross section of a manually back welded 1-inch plate automatically welded from the top side.

Figure 5 shows a close-up view of the "Unionmelt" welding head and the control apparatus for its operation. This picture was taken in the actual operation of welding a circumferential joint of a vessel 19 inches O.D. x $1/2$-inch plate thickness. This illustrates a girth seam being made in the center of a long shell where it is impossible to back up the seam by means of a copper backing-up strip.

Figure 6 is a view showing the complete set-up of a shell and machine for a typical girth seam operation. Figure 7 illustrates the automatic welding head revolved into position and set up for welding a longitudinal seam. Figure 7(*a*) is another view of the set-up for longitudinal seam showing how the bare wire is fed down through a hollow shaft to the welding head. Also is illustrated in the upper right side of the structure the vacuum pick-up system, which is used to reclaim the unfused melt after the welding operation has been completed. In the upper left part of the structure are shown 2—1000 ampere A.C. welding transformers supplying the necessary current to weld up to and including $1\,1/2$-inches thick plate in a single pass.

PHYSICAL AND CHEMICAL TESTS

Figure 8 shows the physical test results obtained from forty-four tests made on 55,000 T.S. plate material per A. S. T. M. Specs. A-70 (A. S. M. E. S-1). These results were obtained on production jobs that have been produced under this process in accordance with the A. S. M. E. Code or the A. P. I.-A. S. M. E. Code for Unfired Pressure Vessels. They represent the average of several jobs of thicknesses varying from $1/4$ to $1\,1/8$-inch thick plate. These physical results are approximately 6% higher than usually obtained with manual bead welding. It will be noted that the full section and reduced section tensile test bars in all cases broke outside of the weld metal. It will also be noted that the per cent elongation for both the face bend and root bend samples exceed in all cases the requirements of the Codes. The purpose of these tests was only to prove that the ductility met the requirements of the Codes and not to establish a point of failure.

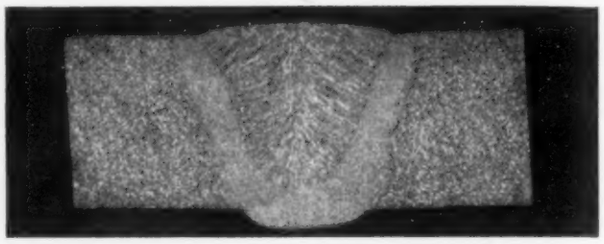


Fig. 4

Figure 9 gives the results obtained on several samples of various thicknesses of flange quality steel plates welded and tested for Charpy impact values. These tests were made in both the "as-welded" condition and the "stress-relieved" condition. The key-hole notch was so placed in relationship to the deposited weld metal as to cover both the top and bottom of the weld and the line of fusion of the weld metal and the plate material. There appears to be very little variation in impact properties with respect to the position of the specimen. It will also be noted that the results obtained where the test section was taken at the parting line of the dendrites show excellent impact values.

Figure 10 shows Brinell hardness values taken across sections of several welds as shown. The deposited weld metal is about 18 points Brinell higher than the plate material, and only slightly harder than the heat-affected zone. The maximum hardness indicated is only 150 Brinell, which proves that the weld metal is in a soft ductile condition.

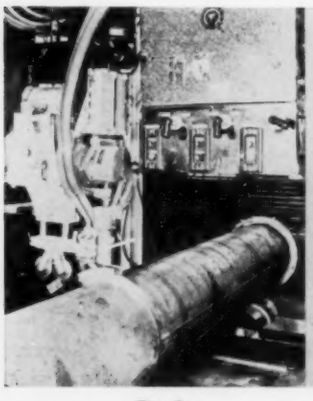


Fig 5

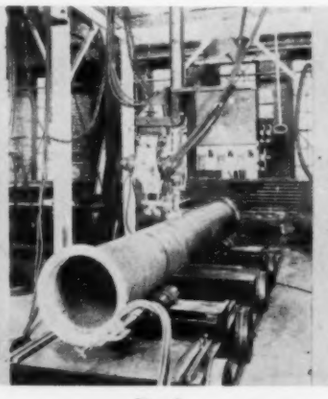


Fig. 6

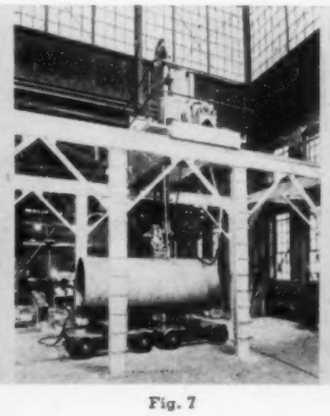


Fig. 7

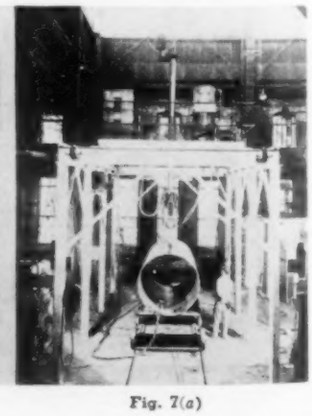


Fig. 7(*a*)

Weld Physical Tests
55,000# T.S. A.S.T.M. A-70 (S-1) Steel Plate

Plate Thickness	No. of Tests	Full Sect. Tensile	Red. Sect. Tensile	All-Weld Tensile	Free Bend***	Density	Nick Break or X-ray	Class of Weld
1/4"	3	60650**	69530		F-43.6 R-36.0		OK	API-ASME
5/16"	6*	61460**	67130		F-42.0 R-37.3	7.85	OK	API-ASME
3/8"	3	62250**	67630		F-37.5 R-37.0		OK	API-ASME
7/16"	7*	62480**	69100		F-35.4 R-35.6	7.85	OK	API-ASME
1/2"	7*	61780**	67100		F-34.4 R-36.6	7.85	OK	API-ASME
9/16"	4*	65120**	70840		F-36.0 R-35.2	7.85	OK	API-ASME
5/8"	6*	64170**	68680		F-36.9 R-36.5	7.85	OK	API-ASME
3/4"	2	59310**	62790	64050	F-45.8 R-40.8		OK	API-ASME
13/16"	1*	62630**	63820	65820	F-39.0 R-40.0	7.86	OK	ASME
7/8"	1	55980**	61760	64050	F-52.6 R-41.5		OK	API-ASME
1"	3*	59890**	58750	64050	F-41.2 R-33.3	7.86	OK	API-ASME
1-1/8"	1	61980**		66300	46.4	7.86	OK	ASME
Average	44	62080	64490	64550	F-38.7 R-36.5	7.85		

* Some of the tests in this group were Class I.
** Broke outside of weld in plate.
***Not bent to failure in any case.
Under Free-Bend column, F = face bend
R = reverse bend

Fig. 8

Tests to determine the corrosive action of dilute nitric acid on weld specimens indicate that the deposited weld metal resists the action of corrosion slightly better than the plate material, and that the heat-affected zone adjacent to the deposited weld metal resists corrosive action to a still greater extent. These tests were made of specimens in the "as-welded" condition.

The fatigue endurance limit, as tested on a rotating beam type of machine, has been determined to be between 45 and 55% of the ultimate tensile strength of the steel plate.

Figure 11 gives a typical chemical analysis of S-1 plate material and of the resulting weld metal when joined by this single-pass method of welding. The nitrogen content is but 0.009, indicating complete protection of the molten metal.

MICROSTRUCTURE EXAMINATIONS

Figure 12 shows the location of micro-structure examinations made on a $^3/_4$ inch thick weld sample. The plate preparation was a 45° included angle for a depth of $^9/_{16}$ inch, having an abutting nose $^3/_{16}$ inch thick. This weld was made using 1100 amperes at 37.5 volts, running at a speed of 10.5 inches per minute. This weld was made in a single pass, employing a copper backing up bar. Figures 13, 14, 15 and 16 show the microstructure at the places indicated. It is noted that the heat-affected zone of the plate material at the line of fusion shows considerably coarser structure than is usual with the multiple bead arc weld. As noted above however, all physical tests including impact show excellent properties, and this coarse structure has been definitely proved not to be detrimental.

Figure 17 shows the location of micro-structure examinations made on a weld in $1^1/_8$ inch thick plate material employing a manual back weld. The weld edges were prepared with a 40° included angle $^{13}/_{16}$ inch deep for the automatic weld, with a $^1/_{16}$ inch abutting nose and a back bevel $^1/_4$ inch deep x 90° included angle. The back bevel was welded by depositing 3 beads manually. This automatic weld was made using a $^5/_{16}$ inch diameter electrode employing 1320 amperes at 39 volts, at a speed of $9^3/_8$ inches per minute. Figures 18 through 26 are representative microstructures taken at the various locations shown in Fig. 17.

PLATE QUALITY

Although it has been shown that welds made under this process are of good quality under tensile, bend, fatigue and corrosion tests, and that since they are automatically made, the "human element" is largely eliminated, it is not impossible to make poor welds. As is well known, any automatic process, whether it be multiple bead arc welding or a single-pass method, necessitates the proper careful attention of the fabricator in seeing that the material is not only properly prepared in the shop but also that the material is of good quality.

Much experimental work has been completed on the subject of plate quality for all welding processes, and it has been shown that inclusions, laminations and sulphur banding in the plate material cause considerable trouble in arc welding. The substitution of single-pass welding for multiple bead arc welding does not overcome these troubles which for years have been experienced with poor quality steel plate, although never fully recognized. Excessive sulphur may not be indicated by ordinary chemical analysis because of the standard method of taking samples. However, the location of segregations or sulphur banding can be determined by etching or by sulphur printing. The chemical analysis of samples

Charpy Keyhole Notch
Q-Weld Process of Welding

ASTM A-70 (S-1) Flange Quality Steel Plate - 55000# T.S.

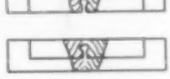
Plate thickness- Condition-	Foot Pounds 7/16" As Welded	1/2" Stress Relieved	5/8" As Welded	1-3/8" As Welded
	31.0 30.0	32.0 31.0	24.0 20.0	24.0 21.0
	42.5 34.8	23.0	27.0 33.0	28.5 33.0
	30.0 33.0	26.0 31.0	22.5 20.0	27.0 25.5
	25.5 24.0	30.5 33.0	24.0 21.0	25.5 24.0
	28.5 30.0	35.0	24.0 22.5	25.5 27.0
Average	30.9	30.5	23.8	26.1

Fig. 9

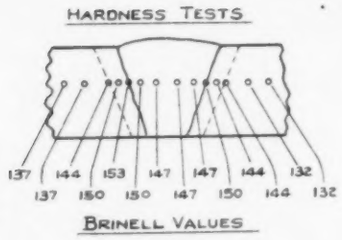


Fig. 10

taken along these bandings in known defective plate shows a sulphur content as high as 0.15%. Such high concentrations of sulphur cause plate weakness and obviously have a harmful effect upon the adjacent weld metal. In the past, troubles from these causes have generally been attributed to poor quality welding electrodes or to the operators, but seldom has the steel plate material been seriously questioned.

Since the "Unionmelt" method is automatic, any consideration of the operator as the cause of defective welds can be eliminated. Furthermore, since the same welding materials and same welding conditions will produce perfect welds in good quality plate and unsatisfactory welds in poor quality plate, it is obvious that plate quality is of great importance.

Figure 27 shows an etched cross-section view of a weld made in plate material having inclusion segregations, and the cracks which occur in the weld metal. Microstructure examinations of these areas as shown in Figs. 28 through 33 indicate inclusions in the plate material and their effect on the fused metal.

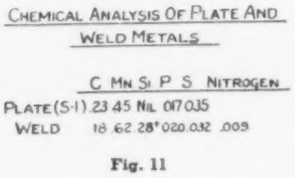


Fig. 11

It should be emphasized that this single-pass method of welding does not require the use of higher cost steels, since satisfactory material is being obtained under the standard specifications. The steel makers have recognized the correctness of the conclusions which have been revealed by investigation of plate material in conjunction with this single-pass method of welding. As a result, welding fabricators are receiving better plate material at no extra cost, and the customer consequently receives a better product, a product having no segregations in the plate material. Whether welded manually or by a single-pass automatic machine or even riveted, plate material should be free of inclusion segregations because of its possible failure in service due to fatigue.

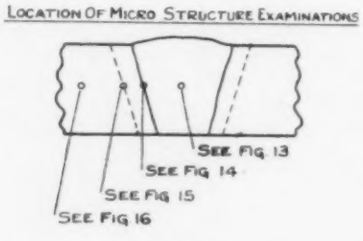


Fig. 12

Experience of over one year with this type of welding has definitely proved that the results obtained are more uniform and superior than is possible where the human element of the welding operator is a major factor in the completion of a successful weld. The percentage of cut-outs for welds made subject to X-ray examination has been reduced to a minimum. On one production job having 13 vessels going through the shop subject to Par. U-69 of the A. S. M. E. Code, X-ray examination was employed to prove the consistency of the welds. A total of 452 X-ray pictures were taken of more than 500 feet of welding, all of which indicated that the welds surpassed Code requirements. The only defects which showed up on these X-ray pictures were found in some of the manual welds used to back up the automatic welding where it was impossible to use a copper backing-up strip. There were no signs of porosity, lack of fusion, incomplete penetration, or other defects in any of the automatic welds, either those backed up with a manual weld, or by using a copper bar.

One of the very important features of this type of welding is the lack of distortion or warping due to welding, which is invariably encountered in manual bead welding. It is not found necessary to reroll a cylindrical shell after welding a longitudinal seam in order to make it round again. There is no appreciable loss in dimension due to welding under this process, eliminating the necessity of allowing for shrinkage due to welding longitudinal or girth seams of a cylindrical vessel.

WELDING OF ALLOYS

Realizing the improvement in quality resulting in welds made under this single-pass method of automatic welding in plain carbon steels, experimental work was undertaken in the welding of chrome-molybdenum, chrome-moly-vanadium, and chrome-nickel steels. During the last few years the steel industry has gone a long way in providing new alloys for the use of those industries demanding steels to withstand excessive heat and corrosion. The oil industry in particular has made use of the 4–6% chrome-molybdenum steel for use at elevated temperatures. This steel, having air hardening characteristics, has presented its problems to the welding engineers.

It has been necessary that during the welding of 4–6% chrome-molybdenum steel that the material be kept in a preheated condition during the welding operation. Oftentimes transverse cracks have appeared visible either to the naked eye, or have shown up upon X-ray examination. The welding of this alloy is an operation that in the past has been possible only under extreme care and close supervision.

Plates of $^3/_8$ inch and $^3/_4$ inch thicknesses of 4–6% chrome-molybdenum of the analysis shown on Fig. 34 were welded under this single-pass method. The welding electrode used was $^1/_4$ inch in diameter, having the analysis as shown in this figure. The $^3/_8$ inch thick plates were prepared with a 60° included angle for bevel, with a $^1/_8$ inch abutting nose. The weld seam was backed up with a 1 inch x 2 inch copper backing up strip and was welded using 30 volts at 850 amperes at a speed of $20^1/_2$ inches per minute. The X-rays of these plates showed the entire seam to be 100% perfect.

The $^3/_4$ inch thick plates were prepared with a 45° included angle and a $^3/_{16}$-inch abutting nose. This weld seam was also backed up with a 1 inch x 2 inch copper

Fig. 13—65,000 Lb. Tensile Steel. Structure of Unaffected Plate. Weld No. 84

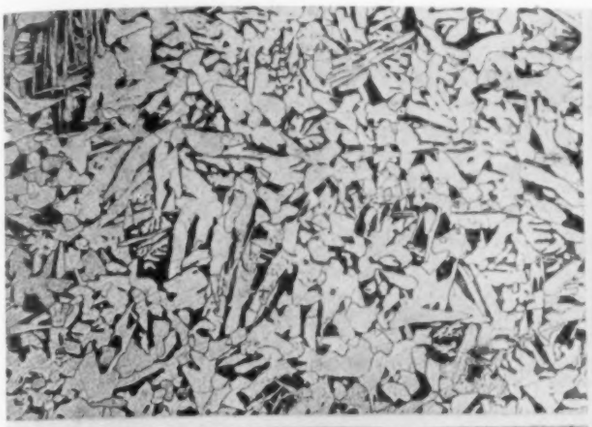


Fig. 14—65,000 Lb. Tensile Steel. Structure at Edge of Plate and Heat-Affected Zone of Plate. Weld No. 84

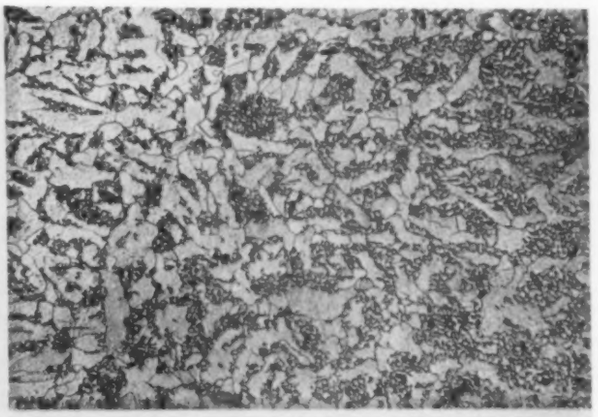


Fig. 15—65,000 Lb. Tensile Steel. Structure at Junction Between Plate (Left) and Weld Metal (Right). Weld No. 84

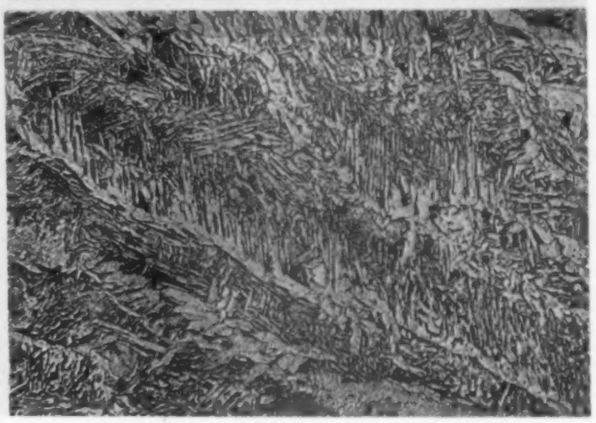


Fig. 16—Structure of Weld Metal. Weld No. 84

backing-up strip and welded using 38 volts at 1240 amperes at a speed of 13 1/2 inches per minute. This weld was proved to be 100% perfect under X-ray examination.

Chemical check of the welds showed typical 4–6% chrome-molybdenum analysis, indicating that the welding operation resulted in no loss of alloy content. In both the 3/8-inch and 3/4-inch plates it is noted that the chemical analysis of the welds shows that the carbon content of the weld metal is midway between the carbon content of the plate and the electrode used for welding. This is also true of the analysis of the weld metal for chromium content. The molybdenum content stayed practically as shown in the original material.

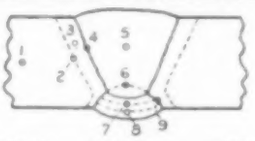
Figure 35 gives physical properties of the welded plate and of the all-weld-metal. It will be seen that the ultimate tensile strength and elongation of the all-weld-metal is very satisfactory. The Charpy impact tests gave an average of 31.7 foot-pounds with the notch in the center of the weld, which is very satisfactory for this material.

The hardness values taken on the welded section showed only slightly higher hardness in the weld metal of the 3/4-inch plate, while in the 3/8-inch plate weld, the weld was slightly harder than plate "*A*" and slightly lower in hardness than plate "*B*." The hardness values over-all may be considered of the same order, indicating fully annealed condition. Figure 36 gives the Rockwell B hardness taken across the plate and weld on both the 3/8-inch and 3/4-inch plates. The blocked-in numbers are in the "all-weld" area.

Micro examination of these welds on both thicknesses of plate reveal very satisfactory fusion with solid weld throughout. Figure 37 shows a macro etch of the two welded samples. Figures 38 through 42 show the micro examinations made of the weld structure.

An actual production job of welding two large 4–6% chrome-molybdenum heat exchangers was undertaken using this single-pass method of welding. All seams were subject to X-ray examination and found to be very satisfactory. There was no chipping or repairing required on any of these welded joints. The cylindrical shell, which was 36 inches I. D. and 1/2 inch thick, was preheated to approximately 200° F. and welded with 1/4 inch diam. electrode using 1020 amperes at 33 volts, running at a speed of 13 inches per minute. Immediately following the completion of the weld, the vessel

LOCATION OF MICRO-STRUCTURE EXAMINATIONS



1-SEE FIG. 18 | 4-SEE FIG. 21 | 7-SEE FIG. 24
2-" " 19 | 5-" " 22 | 8-" " 25
3-" " 20 | 6-" " 23 | 9-" " 26

Fig. 17

was put into the stress-relieving furnace and annealed at 1625° F. for a period of one hour, after which it was furnace cooled to 1000° and then allowed to air cool. The entire vessel was then subjected to X-ray examination and found to be satisfactory in all respects. There were no repairs to be made on any of the seams which were welded with the automatic process. This proved to be a great improvement over any manual welds previously made in this type of material.

The test plates which were attached to the longitudinal seams in accordance with the A. P. I.-A. S. M. E. Code to prove the quality of welds resulting from this process for this particular job gave the following results:

Full section tensile	71,520 lb./ sq. in.
Reduced section tensile	76,500 lb./ sq. in.
Face bend	31% elongation
Reverse bend	32% "

(These samples were not bent to failure, but only to reach the required 30% or greater.)

It is felt that the advantages of this process for welding alloys involving the necessity of preheating and maintaining the proper temperature for welding, followed by a full anneal, has been definitely proved, and that the use of this process will materially improve the quality of the product as well as to lower the cost of production. The

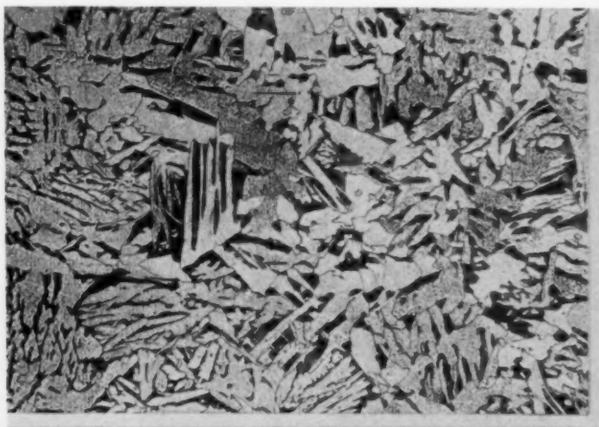


Fig. 18—55,000 Lb. Tensile Steel. Structure of Unaffected Plate. Weld No. 85

Fig. 19—55,000 Lb. Tensile Steel. Structure at Edge of Plate and Heat-Affected Zone of Plate. Weld No. 85

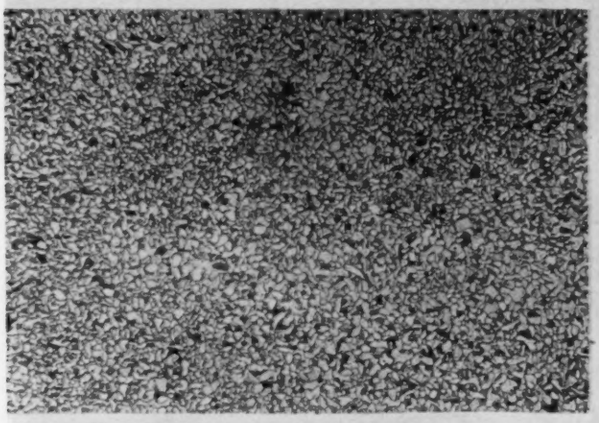


Fig. 20—55,000 Lb. Tensile Steel. Heat-Affected Plate Structure. Weld No. 85

Fig. 21—55,000 Lb. Tensile Steel. Structure at Junction Between Plate (Left) and Weld Metal (Right). Weld No. 85

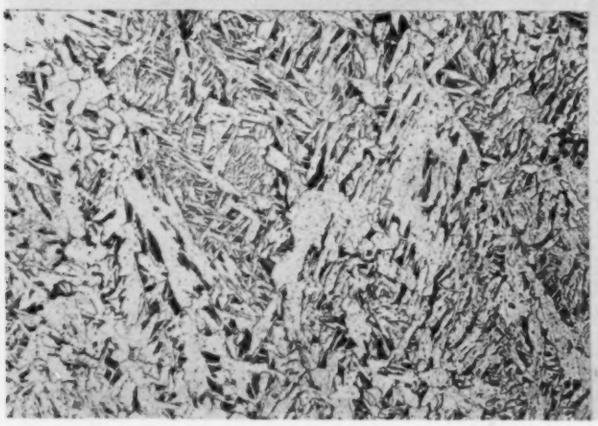


Fig. 22—Structure of Weld Metal. Weld No. 85

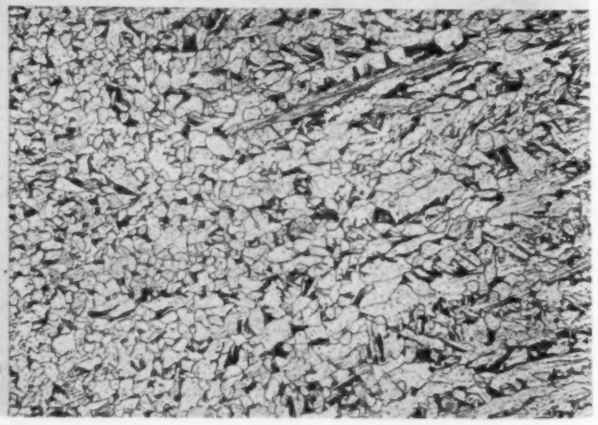
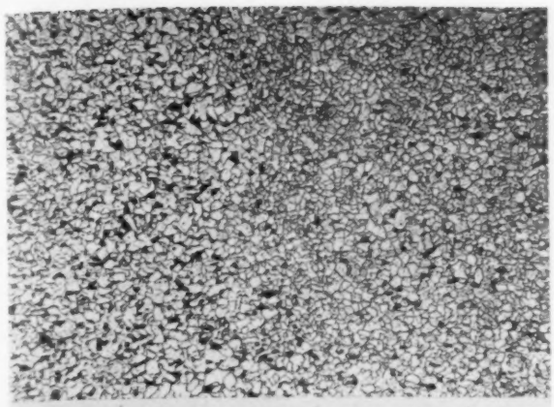


Fig. 23—55,000 Lb. Tensile Steel. Structure at Junction Between Automatic Weld and 1st Bead Manual Back-Weld. Weld No. 85



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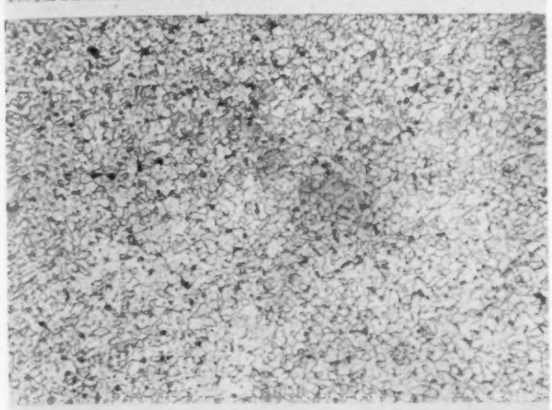

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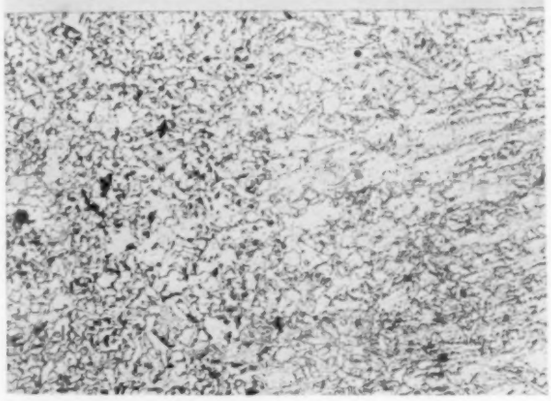


26

Fig. 24—65,000 Lb. Tensile Steel. Structure at Junction Between 1st and 2nd Bead of Manual Back Weld. Weld No. 85

Fig. 25—65,000 Lb. Tensile Steel. Structure of 3d Bead of Manual Back-Weld. Weld No. 85

Fig. 26—65,000 Lb. Tensile Steel. Structure at Junction Between Manual Back-Weld and Plate. Weld No. 85

fact that repairs can be largely eliminated on an alloy of this type means much to the fabricator in the way of cost reduction and improved production scheduling. Slag inclusions, porosity, or lack of fusion, which can so easily happen by multiple bead manual welding, necessitating chipping, re-heating, re-annealing, and re-X-raying, seriously delays production. The physical results indicate the required tensile strength and ductility, and the chemical check of the welds show a typical 4–6% chrome-moly analysis, indicating that the welding operation resulted in no loss of alloy content.

Another alloy that has been successfully welded by this single-pass process is $2^1/_2$ to 3% chrome-moly-vanadium steel, which was used in the construction of three vessels. These units, known as catalyst basket and interchanger shells, are used for the extraction of nitrogen from the atmosphere. The material used in the fabrication of these vessels has the following chemical analysis:

Carbon	0.12–0.20
Manganese	0.50–0.70
Silicon	0.30 max.
Phosphorus	0.04 max
Sulphur	0.04 max.
Chromium	2.5 –3.0
Molybdenum	0.40–0.50
Vanadium	0.20–0.27

This material, which is also air hardening, requires careful handling, and must be properly preheated and maintained at the correct temperature for welding at all times. The method employed in welding these three shells was identical to that employed in the welding of 4–6% chrome-moly. The results obtained were likewise extremely satisfactory. All longitudinal and girth seams were subjected to X-ray examination, which proved that the welds were flawless and exceeded the requirements of the Codes.

Work done on the austenitic type of chrome alloy, one of which is the more commonly known 18–8 chrome-nickel stainless steel, has definitely proved the advantages of this process. Plates of $^3/_4$ inch thick material were welded with $^1/_4$ inch diameter electrode, using a copper backing-up strip and employing 900 amperes at 40 volts with a speed of 12.5 inches per minute. The completed weld showed good penetration with reinforcement of about $^3/_{32}$ inch. The weld metal had the following chemical analysis:

Carbon	0.075
Manganese	0.30
Silicon	0.97
Chromium	18.27
Nickel	10.61
Columbium	0.84
Nitrogen	0.043

Fig. 27—Macro-Section Melt 70—Weld No. 71 Plate X—Cold

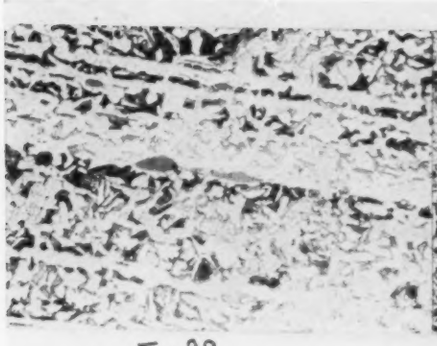


Fig. 28

Plate Structure-Showing Inclusion

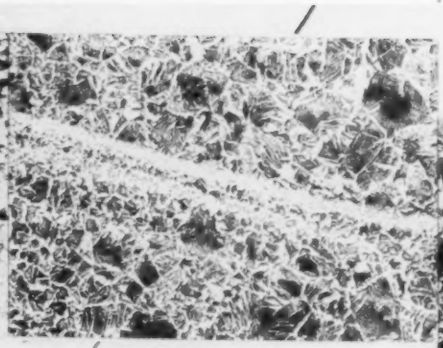


Fig. 29.

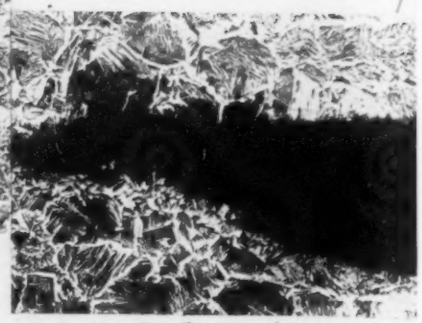


Fig. 30

Heat Affected Zone — Start Of Crack

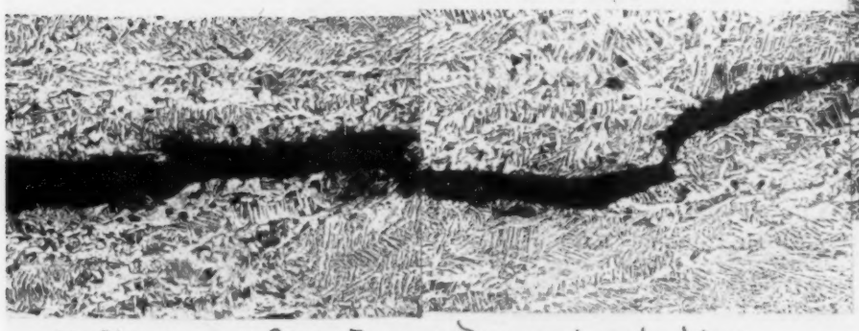


Fig. 31

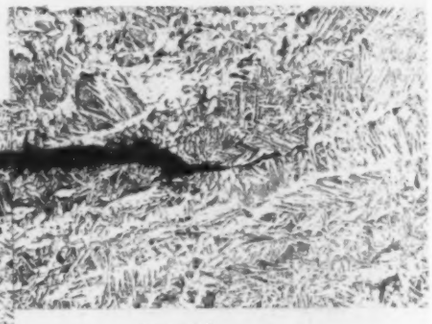


Fig. 33

Crack Following Dendritic Lines Into Weld →

Fig. 32

Chemical Analysis of Plate - 4-6% Chrome-Moly

Plate	C	Mn	P	S	Si	Cr	Ni	Mo
3/8"	.078	.40	.020	.019	.415	4.87	.149	.51
3/4"	.12	.36	.018	.020	.404	5.15	.393	.58

Chemical Analysis of Welding Electrode

Dia.	C	Mn	P	S	Si	Cr	Ni	Mo
1/4"	.095	.38	.017	.014	.419	5.23	.208	.54

Chemical Analysis of Welds

	C	Mn	Si	Cr	Mo
3/8" plate weld	.081	.29	.56	5.12	.53
3/4" plate weld	.109	.29	.54	5.06	.51

Fig. 34

Physical Properties of Weld Metal - 4-6% Chrome-Moly

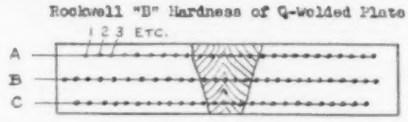
Weld	Test Size	Treatment	Tensile	El. 2"
3/8" plate	2" x .402	Annealed at 1625° F. for 1 hr.	70610	25.0
3/4" plate	2" x .505		78740	20.5

Physical Properties of Welded Plate - Reduced Section Weld Test Bars

Piece	Test Size	Treatment	Tensile	Break
3/8" plate	.376 x 1.495	Annealed at 1625° F. for 1 hr.	67390	Outside weld
3/4" plate	.735 x 1.493	"	77510	Partly in weld, partly in parent metal.

Fig. 35

Rockwell "B" Hardness of Q-welded Plate



Hardness impressions taken at approximately 1/8" intervals from the edge of each plate across the weld to the opposite edge.

Location	3/8" Plate			3/4" Plate		
	Line A	Line B	Line C	Line A	Line B	Line C
1	66	70	69	75.5	76.5	76
2	68	72	69	76.5	76.5	75
3	68.5	71.5	70	75.5	76	75.5
4	70	71.5	70	75.5	77	73
5	71	71.5	71	75	77	75
6	71	72	71	76	76.5	76
7	72	72	70	76	76.5	75.5
8	73.5	72.5	69.5	76	78.5	78.5
9	72	72	71	76	77.5	76
10	73	71.5	70	77	80.5	77
11	72	72	68	80	79.5	79.5
12	73	74.5	68.5	80	79	79
13	73	75	73	79	78	79
14	72	74.5	73	80	78.5	79
15	73.5	74.5	71	80	78.5	78.5
16	73	74	73	79	78	76
17	76	74.5	76	80	77.5	75.5
18	75.5	75	74	80	77	73.5
19	75	75.5	76	78	77	75
20	75	75	76	77	76.5	74
21	76	74.5	75	76	77	74.5
22	75	75	74	76	77	74
23	76	75.5	72	76	77	73.5
24	75	75.5	73	76.5	77	74
25	75	75	73	76		
26	75	75	75	76.5		
27	75	74				
28	75					

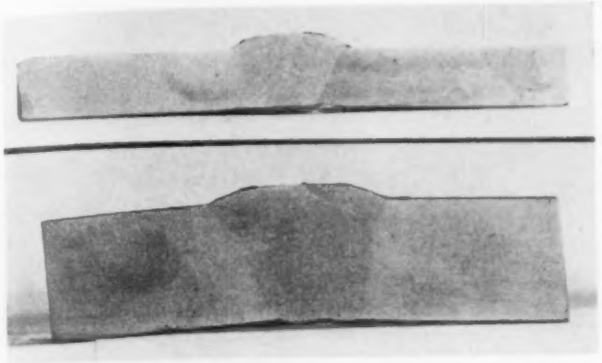
The blocked-in numbers are in the "All-Weld" area.

Fig. 36

The nitrogen content corresponds to the usual amount found in 18–8 chrome-nickel alloy and indicates that there has been complete protection of the molten metal.

Physical tests gave the following results:

Fig. 37—4-6% Chr. Mo. Steel. Welded Section Polished and Etched Slightly in 20% HCL



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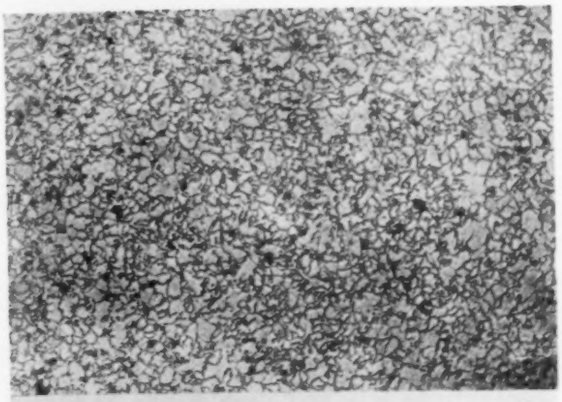

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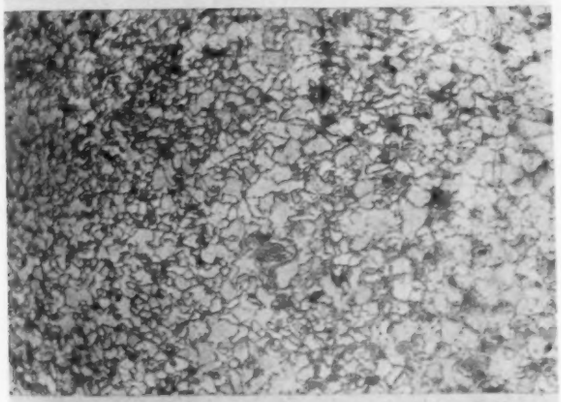

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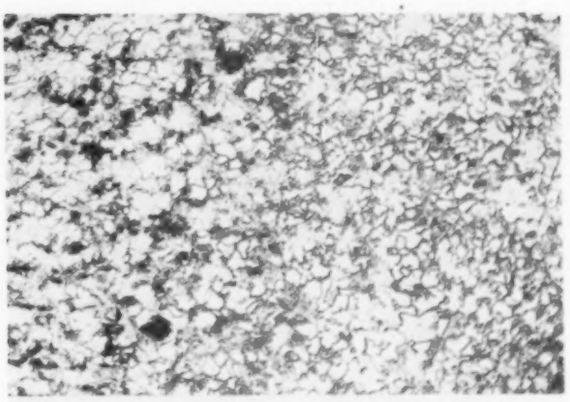
Fig. 38—$^3/_4$ Inch—4-6% Chr. Mo. Plate. Annealed Structure—Ferrite and Carbides

Fig. 39—$^3/_4$ Inch—4-6% Chr. Mo. Weld. Weld Junction. Left Side—Plate Material. Right Side—Weld Metal

Fig. 40—$^3/_4$ Inch—4-6% Chr. Mo. Weld. Annealed—Weld Metal

Fig. 41—$^3/_4$ Inch—4-6% Chr. Mo. Weld. Weld Junction. Left Side— Plate Material. Right Side—Weld Metal



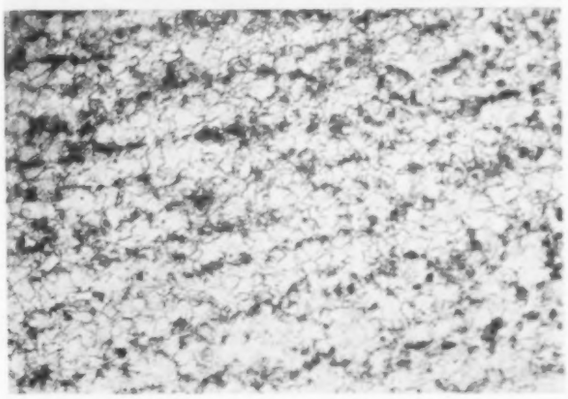


Fig. 42—$^3/_4$ Inch—4-6% Chr. Mo. Weld. Annealed—Weld Metal

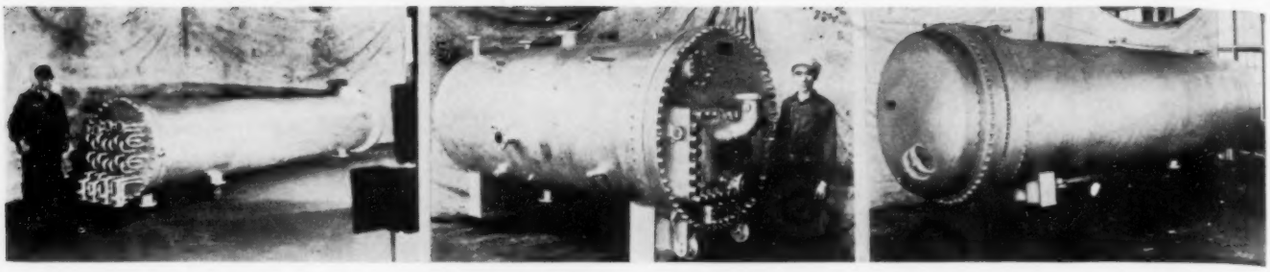
All-weld-metal tensile test yield point	40,000 lb./sq. in.
Ultimate tensile strength	76,450 lb./sq. in.
Per cent elongation in 1.5 inches	53.4
Per cent reduction of area	56.6
Izod impact test, all-weld specimen	top notch 55.5 ft.-lb. side notch 56.0 ft.-lb.

Free-bend test, longitudinal all-weld specimen—outside fiber elongation 40% in $^1/_2$ inch length—40% in 1 inch length.

Corrosion tests given the standard three period test in boiling 65% nitric acid showed the corrosion rate to be comparable with that obtained with rolled plate.

CONCLUSION

From our experience in over one year of successfully welding random types of unfired pressure vessels with the single-pass method of welding, it has been determined that consistent results are obtained with improved quality. As shown above, all physical tests and chemical analysis as well as micro-structure examinations have indicated excellent weld properties. The fact that the difficulties experienced with plate quality earlier in the year have been successfully overcome and that the steel mills are now furnishing plate material guaranteed to be suitable for single-pass welding, and that since the steel mills have been fully aware of the trouble experienced earlier, not a single plate has been found to be defective and that no cracking of welds or other defects due to inclusion segregations in the plate or any other reasons has occured, is proof of the quality of welding. It is definite



Typical Units Welded by the Automatic Process

indication that progress has been made both in the art of welding and in the art of steel making. This insures to the buyer a better product. The future should show even greater possibilities in its application to alloys used for heat exchanger service subject to high temperatures, high pressures and severe corrosion.

MANUFACTURE OF REAR AXLE Housing*

By E. L. BAILEY† and V. KNECHT‡

IN REVIEWING the literature on welding for the past year, I find the majority of reports and papers are on Arc Welding. However, Electric Resistance Welding, which applies electric current in a very simple manner, to do useful work, is still considered by many, the world's best assembly method. Resistance welding is used to assemble a wide diversity of parts. For example, the metal radio tubes using a few amperes for a single cycle, and the automobile rear axle housing using half a million amperes for 7 or 8 seconds are resistance welds, both processes being economical and extremely reliable.

The technical and commercial success of the resistance welded Rear Axle Housing is due to several factors. First, the design is a very simple form, making the dies and gages easy of manufacture. Next, presses are used to cut the blanks and form them into the shape for welding. This may sound simple, but the greatest care must be used to form the material so that strains are not left in the metal and further that the dimensions are rigidly kept.

Our practices in die design and press operation are the result of years of experience in making sheet metal automobile parts, where high production has taught us to make good dies, good positioning devices, and to use good presses. The preparation of the part to be welded as outlined above, is most important.

Finally, supplying correct and ample power together of course with correct pressure and timing, makes this method of assembly entirely satisfactory and permits the production of a complete automobile axle housing, which means a new automobile, every 13.5 seconds.

In detail the process is carried on as follows: The rough stock is purchased in a flat sheet form, which is punched out to exact dimensions. There are three flat pieces used for each half of the main assembly. The three pieces are welded end to end by two resistance type welders to form a narrow flat bar of stock about 6 feet long. This becomes the blank that is later pressed to form. The welding of the two ends to the center part is done in completely automatic resistance welders, one for each end. The blanks are merely laid into the dies, a lever is pulled clamping the parts and the machine carries the process through for a complete weld. In this type of weld there is considerable "Flash" which has to be removed by a stripping operation. The built up blank now having two welds is sent to the first forming press where it is drawn into a semi-tubular section. Next, it goes to a Coining Press which gives accurate dimensions to the edges which later are to be welded. We have found this an advisable operation in order to give a 100% weld later on.

The cover plate reinforcement, a crescent shaped piece of steel, is next welded on to the center of this by means of a three-phase projection welder. This machine of 600 kva. capacity does an excellent job of securing this reinforcing member into the housing where the differential is later to be mounted, but it requires a good power supply.

Two such parts lightly tacked together to form a tubular member now goes to the main Metropolitan Welder where a half million amperes is driven through the contact faces to make a 112-inch resistance weld. This is quite a spectacular performance, as of course, there is considerable "Flash" as the power involved is over a 2000 kva. The operation of this welder is in reality very simple. The two parts to be welded are simply laid in the lower half of the dies in a horizontal position. The dies are then closed firmly together by pneumatic cylinders and the current is applied by closing the exciter circuit on a generator which delivers 10,000 amperes at 280 volts single phase 60 cycles.

This scheme of applying the power through a motor generator set is necessary to relieve the power system of

* Paper presented at Annual Meeting, A. W. S., Detroit, Mich., Oct. 16 to 21, 1938.

† Electrical Engineer, General Master Mechanic's Division, Chrysler Corporation, Detroit.

‡ Chrysler Corporation, Detroit.

too great a shock. The current is applied for approximately 7 seconds while an electromagnetic mechanism puts increasing pressure on the dies so that the entire length of weld is firm and complete. The excitation is then removed from the generator and the current dies down and the weld is complete. The tubular assembly is now removed from the die and taken by conveyor to a furnace for heating the ends so that they can be upset to form the wheel bearing housing. After this operation the "Flash" is removed from the inside of the assembly. The spring seat pads are then projection welded into place. The cover is now attached by automatic arc welding, and axle housing is complete and ready for machining and final shipment to the division where the completed axle housing is to be used.

The power supply for the two Metropolitan Welders has had an interesting development.

The first welder purchased some ten or eleven years ago was designed for 440 volts, 5000 amperes. There was furnished with this welder, a synchronous motor driven single-phase generator rated for 440 volts, 3500 amperes 60% PF. This equipment operated satisfactorily for some years on a limited production starting at about forty axles per hour, and a yearly production of less than 100,000 axles.

However, a greater output was required each succeeding year and the welder began to show evidence of overloads. A new welder was purchased in 1933 and the schedule moved up for more axles. Then, the 1470 horsepower motor generator set was in trouble, so a new large 2500 horsepower flywheel type induction motor drive set was installed late in 1934 together with switching equipment which would permit connecting first one welder then the other to the generator so that the generator could service the two welders. This arrangement has permitted a production of 135 axles per hour on each of the two welders used alternately, total of 270 axles per hour and a yearly production of over 1,000,000 axles.

A recent development applied to this installation is unique, in that it is an attempt to improve the over-all electrical efficiency of operation of the department. As is well known, welders, and large motors running at light loads for a considerable portion of their operating time, produces a very low power factor so that the power factor of this department had to be improved in order to obtain the best power rates from the Power Company. We decided to use the old synchronous motor driven motor generator set to operate the welders, as we found that the actual voltage required on the welder circuit was not 440 volts but 270 volts and further that the power factor of the welding circuit was approximately 60%, so that by installing a 440/270 volt auto-transformer and 440-volt static condensers, we could deliver the correct kva. to the welder and still not overload the generator, as the condensers and the transformers permitted us to operate the generator at normal full load 85% power factor and normal voltage.

I have emphasized the electrical power treatment for this Axle Housing Welding Plant as correct and ample power is a material factor in the success of any large resistance welding process.

WELDING of SMALL SUBASSEMBLIES in a Program of All-Welded Machines*

By E. J. DE WITT†

OF PRIME importance to the machine designer are the many units which make the machine proper. These units are most troublesome on the type of machines now demanded by the machine buying public.

The current trend to fully automatic features has resulted in a great number of subassemblies in each machine. These subassemblies are more complex. As these units become increasingly difficult for the pattern maker and foundry man, they provide a greater range for the welding designer. By that is meant the field for the welding designer will be broadened if the pattern and foundry expense is high.

As an example the bending arm of the older style of benders had only one function. It provided a means of support for the larger diameter forms. This called for a simple inverted channel section as light as possible but with no reason other than the material economy for this lightness. The present bending arm, however, is used to support and drive the form, support the clamp block, move it up to the work to provide a positive grip on the pipe, automatically release this grip and rotate at speeds of 4 to 10 times those at which the former arm worked. This is a good item for arc-welded design as the pattern cost would be high, the material usage wasteful and weight excessive. Whereas, with the old type arm, the only thing in favor of welding would be the economy of weight. This is not functionally essential. This saving would be partially offset by increasing machining time.

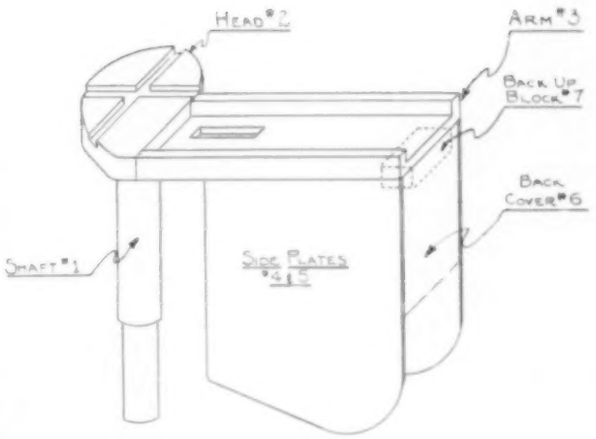


FIG. 1

An analysis of these two comparable problems made by our company would be along the following lines. The old style arm is the first example. Its purpose, as previously explained, is to hold up or support a simple

* Paper presented at Annual Meeting, A. W. S., Oct. 16 to 21, 1938.
† Vice-President, Wallace Supplies Mfg. Co., Chicago, Ill.

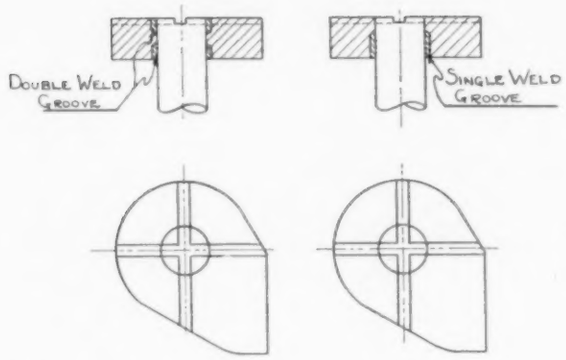


Fig. 2 Fig. 3

load. This is rough machined on the top surface. There are no mechanical objections to weight nor are there any mechanical objections to cast construction. Pattern expense on this item is low. In favor of welded construction would be a lighter arm for equal strength; no pattern expense would be involved. A cost comparison of these two problems both welded and cast is itemized below:

	Welded	Cast Construction
Weight	475 lb.	600 lb.
*Cost per lb.	4.15 lb. Raw. Mat.	6.3 lb.
	$20.71	$37.80
Weld. Dwgs.	8.00	Patt. 24.00
Flame cut	3.75	....
Set-up and weld	12.20	....
†Machining	7.20	6.65
	$51.86	$68.45

*Above based on the amount involved as a warehouse purchase.
†Machining time includes overhead.

It is our custom to write off pattern or engineering expense on the first job run because of the special nature of these jobs. If, however, subsequent items were to be made, the cost comparison would be as follows:

	Welded	Cast Construction
Cost	$43.86	$44.45

As the castings are generous of section, the likelihood of rejects being disclosed by the machining operation is slight. Inasmuch as the speed of the machine is slow, the light weight of the welded construction would have no functional advantage.

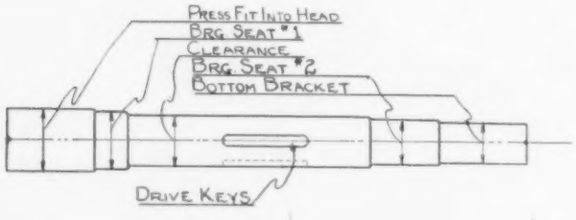


Fig. 4

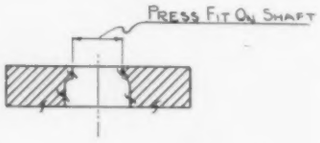


Fig. 5

The given figures based on our shop conditions would not apply in other shops where annealing equipment is available. Lacking the room for annealing ovens, a careful procedure routine has been developed to keep warp at a minimum and stress at the lowest possible value.

As a result the cost per foot of weld is much higher than figures usually given for this type of cost comparison. Shops which use lower figures will have to add at least 1¢ per pound for normalizing which will bring the final figure close to our figure. This averages approximately $3.00 per hour including a helper to clean welds and assist in bulky set-ups. It has been our practice to weld wherever possible, if no penalty is involved for so doing. Consequently the old style arm if being made today would be welded as its indicated cost is slightly lower both before and after the initial write-off of pattern and engineering expense.

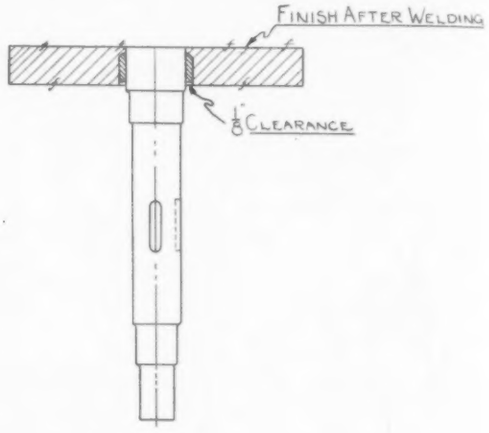


Fig. 6

This type of job does not make a good item for a designer to select as an error of 5% in estimated welding time would show a loss as compared to the same item cast.

The arm for an automatic bender is a different story. Here there are many reasons of a mechanical and functional nature, as well as possible savings in the cost of the finished item. The following are the functional reasons for a light weight unit. First, it is necessary to stop rotation at a predetermined point while operating at speeds of 10 to 15 revolutions per minute with a minimum jar on the mechanical drive system. Second, this arm contains a hydraulic cylinder and clamping mechanism within the body of the arm. Maximum space is required. Third, a maximum strength connection is required to the head shaft as this arm now is a force transmitting agency.

Below is an itemized cost comparison:

	Welded	Cast (Steel)
Weight	518 lb.	790 lb.
*Cost per lb.	4.15 lb.	9.2 lb.
Total material	$21.50	$72.68
Flame cut	5.05	....
Set-up and weld	16.20	....
†Machining	21.00	26.00
Drawing	12.00	Patt. 108.00
	$75.75	$206.68
		Less
Less drawing	12.00	Patt. 108.00
	$63.75	$ 98.68

*Based on warehouse price.
†Labor includes overhead.

Here the designer has a clear field in favor of welded construction even against a long run machine as the welded cost is approximately two-thirds of the cost of the cast arm. In addition the sections of the cast side plates will be somewhat of a gamble because of the depth and thinness of the desired section. The drive mechanism can be welded to either type arm but the weld strength of the cast-steel arm will be slightly lower as the density of the metal in the casting will be lower. It will also lack the hot worked characteristics of the arc-welded unit.

The following points outlined are in favor of the welded subassembly over the cast subassembly:

1. It saves a high pattern charge.
2. The cost is less when in comparable condition to the rough casting, that is, cost of material plus welding labor as compared to cost of casting as received from foundry.
3. It has known strength with desired lightness.
4. It has no sand inclusions and will machine more readily.
5. There is little possibility of condemning defects showing up in machining.
6. It is almost certain to be free of internal voids.
7. Additional work in welding department tends to lower general overhead.
8. Lighter side walls of rolled steel plate provide more room for assembly of clamp cylinder and toggle links within the arm, positively maintaining the desired strength in these plates.
9. It gives the designer a free hand as to appearance by removing the restrictions imposed by foundry practice.
10. Finished arm when welded requires less preparation of large surfaces to make a satisfactory appearance.

Having decided to weld the next step is to lay out for welded design. Based on past experience our practice has been to finish machine as many parts as possible prior to welding these parts into the subassembly. With this practice in mind the design problem is approached as a preliminary search to find these parts. See Fig. 1. The analysis shows 7 parts required in this welded subassembly. Of these *The Main Shaft*, Part 1, *Head Shaft*, Part 2 and *The Bending Arm Proper*, Part 3 are finished machined. Part 1, Main Shaft is subject to high torsional load and should be an alloy with a high yield point but have a Brinell sufficiently low to permit ready machining. Part 2, The Head, and Part 3, The Bending Arm should be low-carbon steel. Ample section can be allotted to these parts to permit the proper amount of welding to be done on them. From the viewpoint of machinability as well as high yield S. A. E. 3140 or S. A. E. 4140 would be satisfactory for this shaft. However, the chrome contained in these steels combined with the high-carbon content produces an air hardening steel which when welded has a practically unmachinable area. The weld area will also contain an exceedingly high stress center. This is a condition very much to be avoided in this particular part. Surface cracks and checks will result from cold welding either of these two shafts. S. A. E. 2320 can be procured with a Brinell of approximately 280 which is machinable, a yield point of approximately 110,000 lb. per square inch which is satisfactory and if a heat is obtained with a carbon content of less than 20 points, the shaft when welded will show little air hardening effects. It will show only a slight increase in the Brinell. This will not seriously effect its machinability. Experience with these different alloys on the actual machining on the cross keyways of Part 2 after it has been welded to Part 1 showed the following costs:

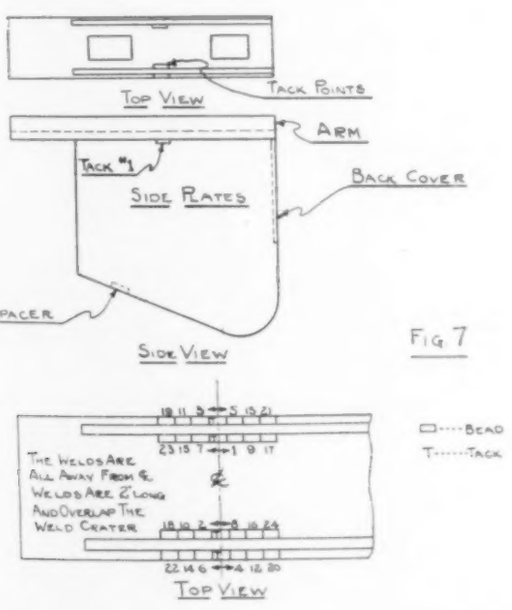


Fig. 7

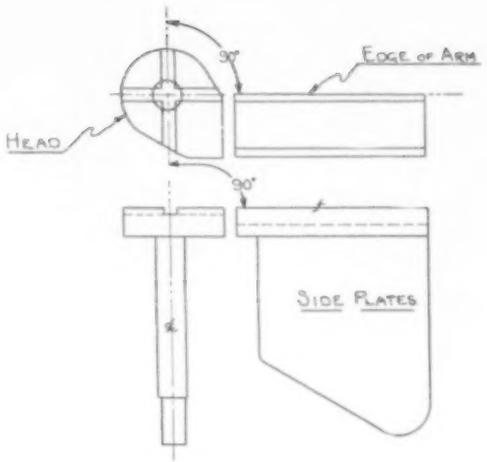


Fig. 8

S. A. E. 4135 (0.32 carbon content) 8 hr. 55 mins.
S. A. E. 3120 (0.19 carbon content) 6 hr. 30 mins.
S. A. E. 2320 (0.16 carbon content) 3 hr. 40 mins.

Each of these arms was subjected to maximum torsional loads with the following results:

S. A. E. 4135—Shaft fractured $^3/_8$ inch below weld.
S. A. E. 3120—Shaft fractured $^3/_4$ inch below weld.
S. A. E. 2320—Shaft unimpaired.

Torque used in this test was a force of 58,300 lb. applied on the 14-inch lever.

Having decided on S. A. E. 2320 as a result of aforementioned tests, the next step was to determine a welding set-up for uniting the shaft to the head plate Parts 1 and 2. If the welding set-up were to be made as shown in Fig. 2 it would be necessary to machine through the welded area in order to cut the keyways. This is objec-

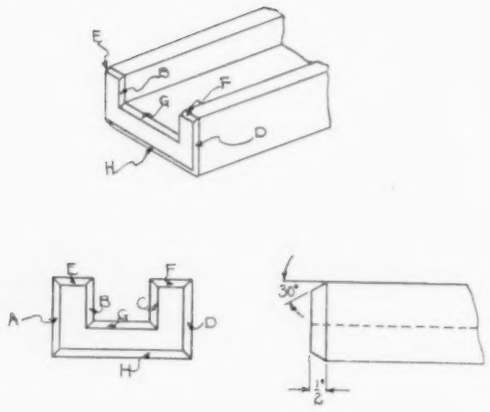


FIG. 9

tionable for two reasons. First, it removes part of the weld strength, and second, it means machining Part 2 from both sides in the preparation of the welding groove. This involves a double set-up resulting in unnecessary cost increase. If the same amount of welding groove were made as shown in Fig. 3 it would be possible to stop the weld short of the bottom line of the plate, machine through the unwelded area and have full advantage of the entire body of weld-metal. The preparation of the shaft as shown in Fig. 4 is a simple lathe job. The keyways may be either shaped or milled. Machining of the head is as shown on Fig. 5. After these two parts are prepared they are pressed together as shown in Fig. 6, then welded. The welding groove is not entirely filled. This is shown by the $^1/_8$-inch clearance allowed as per Fig. 6. These two parts are then mounted between centers, and the top surface of the head turned at right angles to the center line of the shaft after which keyways are cut. The next step is to prepare Parts 3, 4 and 5. It is obviously easier to finish machine Part 3 before welding on any of the other parts to it. This means extreme care in welding on the side and end plates to the arm unit as a cast-iron slide, Part 8, must be a snug slide fit with Part 3 in the final assembly. Warp, after Part 3 was finished, would destroy the quality of this fit and is therefore, something which must be avoided at all cost. After a great deal of experimental work we found that the warp could be controlled enough to permit fitting of Parts 3 and 8 by a minimum of scraper work and filing. The procedure to get these results is simple. First, Plate 3 is clamped to a large surface table which formerly was the bed of 20-foot stroke-planer made obsolete by the change to arc-welded construction. This plate is clamped with shims of the correct amount under the center of the plate putting a bow of about eight-thousandths of an inch for each 12 inches of length. As the average arm is approximately 2 feet, the amount of bow required is only $^1/_{64}$ inch. The side plates 4 and 5 are then tacked into place as shown in Fig. 7. After this the end plate 6 is tacked to the now properly spaced side plates. A bar of $^1/_2$ x 2 inch strip is tack welded on the extreme end of the side plates making the side and end plates into a loose box section which will tend to reduce lateral movement of these plates while the welds later to be made are cooling. The welding is then done as follows: alternate welds are made worked outward from the center lines and first tack welds (see Fig. 7). This procedure results in no weld being tacked onto another weld until seven welds have been made elsewhere on the assembly. The time one weld is allowed to cool before the next weld is spliced to it averages 5 to 8 minutes. This procedure leaves the finished piece sufficiently cool so that the hand can be placed within a few inches on the welded area without excessive discomfort. Vertical welds are next placed on the outside of the back plate. The purpose of the vertical weld is to produce a welded surface which will require a minimum of work to finish. After the whole assembly has cooled to room temperature the clamps are released and a fillet weld is placed on the inside of the joint between the side plates and the back cover. The finished group of Parts 3, 4, 5 and 6 are now ready to have the back-up Block 7 welded in place. This part, which is at the extreme end of the bending arm, is welded with a down-hand $^3/_{16}$ inch diameter rod. The location of the part prevents any damage by warping, and the arm subassembly is now ready to weld to the subassembly of the main shaft and head.

This problem is even more delicate than the preceding two. After the head had been welded to the shaft these two pieces were finished on the top as previously explained and the cross keys were cut. It is absolutely imperative that these cross keyways be accurately parallel with the finished side slide surface of the arm and that the shaft itself be absolutely at right angles to the bottom finished surface of the bending arm (see Fig. 8).

The function of this arm is to rotate at right angles to the frame of the machine, and this function must be correctly interpreted by the welder in joining these two subassemblies if this machine is to do the work for which it is intended.

In order to permit a margin of safety in this operation the following procedure has been developed through experience. Figure 9 shows the way the weld grooves are prepared by the flame cutting machine. Surfaces *A*, *B*, *C*, *D*, *E*, *F*, *G* and *H* are tapered at 30 degree angle from the surfaces indicated in the sketch. The parts are then set together as shown in Fig. 10. The bending arm subassembly is free to move up or down but not sideways while head shaft assembly is clamped rigidly to the surface plate. Surfaces *A* and *D* of Fig. 9 are welded securely to the head shaft providing accurate alignment of the cross keyways to the finished side surface of the slide. After these welds are made the shaft is released from its clamps, the piece then turned to permit the welding of surfaces *B* and *C*. These are welded solid leaving surfaces *E*, *F*, *G* and *H* to be welded. All this welding is done with $^5/_{32}$ inch down-hand rod. Welds are 1 to $1^1/_2$ inches long. These welds are peened lightly while still

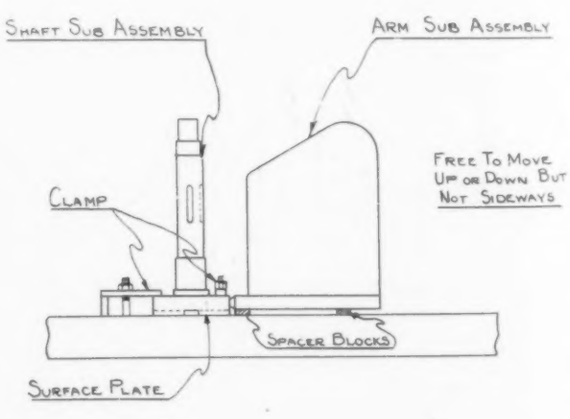


FIG. 10

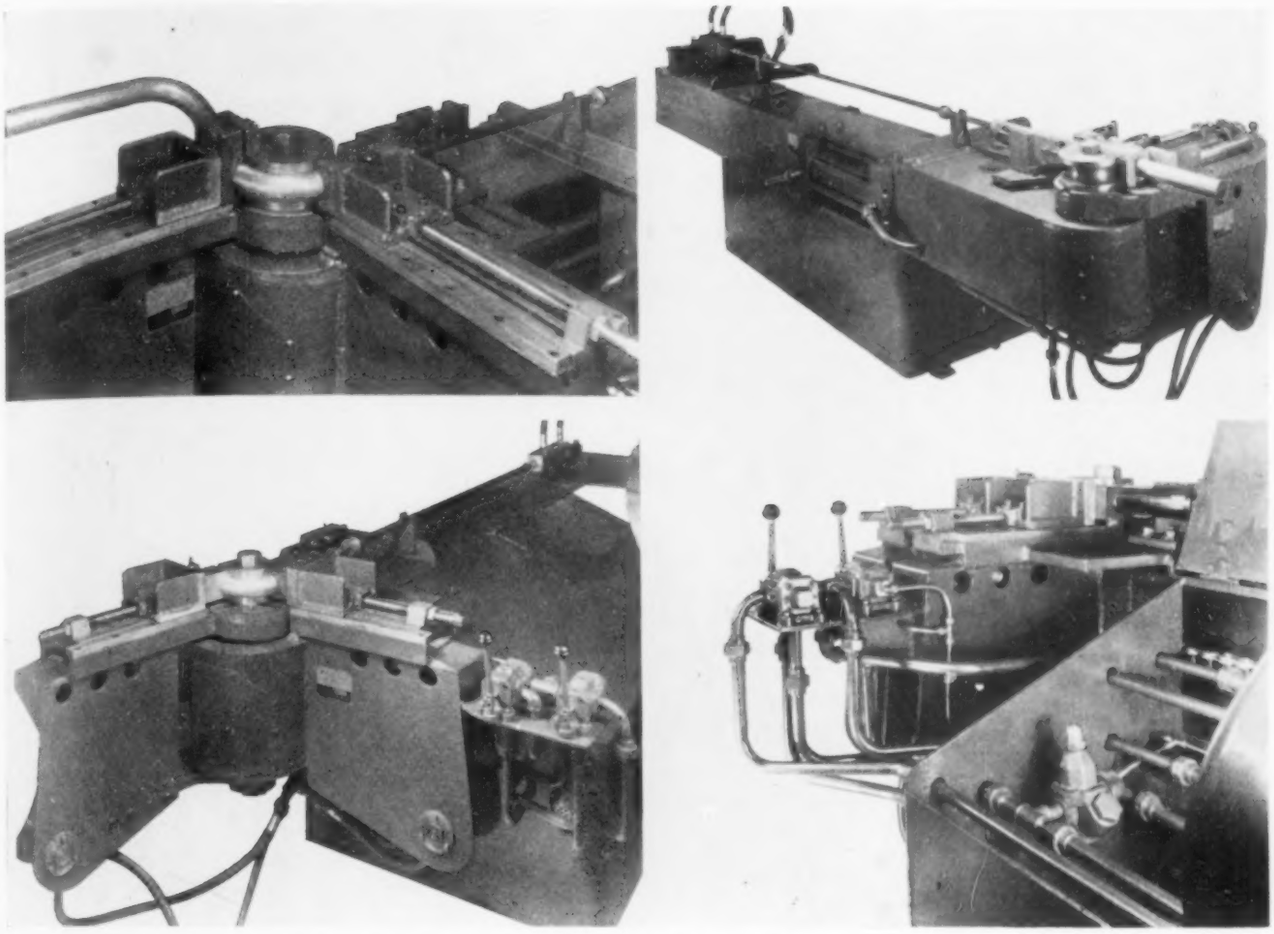


Fig. 11—View Illustrating Welded Construction in the Manufacture of Benders

hot. The entire assembly is turned frequently until surfaces *E*, *F*, *G* and *H* are welded within one layer of the top. This top weld or pass is made at right angles to the previous beads and as a consequence the welds in this pass will not be over one-half inch to five-eighth inches long. Relationship of the shaft to the slide is checked often and carefully during this final welding as the placing of the final bead may make the difference between success and failure.

A series of checks made on several different methods of fabricating this particular subassembly were made and the above described method was adopted as being the cheapest and most satisfactory from a fabricating standpoint.

Taken as a whole the problem of design for welding is most interesting because of the great flexibility and freedom which a designer enjoys through this relatively new fabricating medium.

If care is taken in breaking down a machine into its component parts, if these components are considered as individual problems then the designer is off to a flying start. He will have instead of a complex mechanism a simple unit which can in most instances be worked out in its entirety independent of the rest of the machine. He will find as he delves into the art, and it is an art, that practically anything can be built of welded steel. All that is required is thought, experience and properly trained personnel.

Eliminating Warpage

By H. B. GILSON*

BULGES REMOVED FROM STEEL PLATE AND CASTINGS BY OXYACETYLENE HEATING

THE effects of expansion and contraction in welding or cutting with an oxyacetylene flame are well known. Methods have been developed to control and direct these effects, and to correct them should warpage or distortion result. The following examples of how warpage can be overcome by subsequent heating are typical of the many instances where the same flame can be used effectively to bring the piece back to its original shape.

In the sketch below is shown a circular plate $1^3/_4$ inches thick and 10 feet in diameter, which has seven circular openings formed entirely by flame cutting. A quantity of these plates had been produced and it was found that some warpage invariably occurred, either at some point along the edge or in the body between two of the openings. In the specific case illustrated, distortion in the form of high spots or bulges occurred at both points *A*

* The Linde Air Products Company, Milwaukee.

and *B*. At *A* the plates buckled to a height of about 1 inch, while at *B* the edge curled until it was about $^1/_4$ inch out of line. The double cross-hatched areas indicate the limits of the warped material.

STRAIGHTENING PROCEDURE

To straighten the piece, the two warped places were heated at the highest points, as indicated by the dark areas, with two blowpipes to a temperature of about 800° F., or in the black heat range. They were then cooled rapidly with compressed air at 80 lb. per sq. in. from two $^1/_4$-inch hoses. It was found, in the case of section *A*, that the plate returned about $^1/_2$ inch toward flatness after one treatment; it was therefore heated and cooled twice to complete the operation. The warpage at *B* was corrected with similar treatment after one heating.

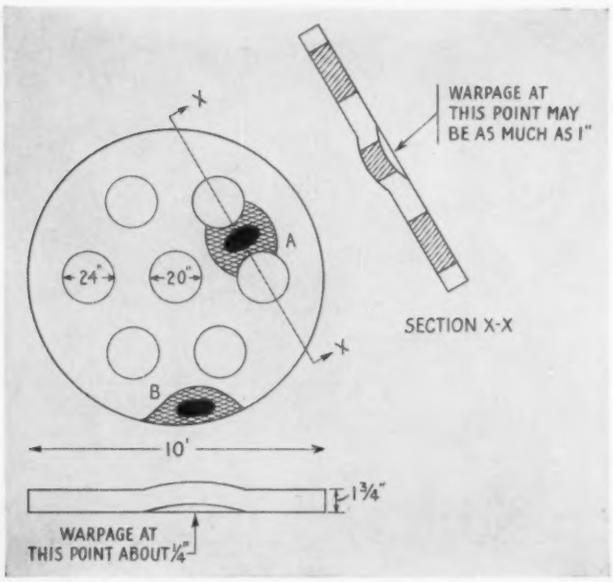


Fig. 1—Warpage at "A" and "B" Was Overcome by Heating the Dark Spots in the Double Cross-Hatched Areas

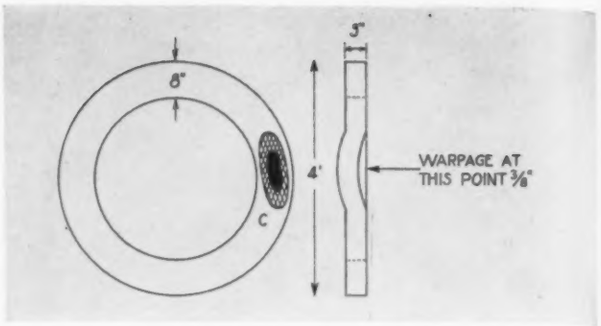


Fig. 2—The Blowpipe Eliminated Distortion at Point "C" in This Cast Steel Ring in One-Quarter the Time Formerly Required

Heretofore, these parts were straightened in a press, 32 man-hours being required for each plate. By use of the blowpipe, three plates were straightened in 2 hours and the maximum variation after treatment was $^1/_{16}$ inch, all of which was removed by subsequent machining. It was at first thought that some strains might have been set up by the heating operation which would be relieved by machining, but such was not the case.

ALLOY STEEL RINGS

The sketch, Fig. 2, illustrates how blowpipe straightening can be employed to correct distortion resulting from procedures other than flame cutting.

This application was developed in the same plant. The ring shown is an alloy steel casting formerly straightened in a press, an operation that required 16 man-hours. After straightening, the rings were stress-relieved in a furnace where they had to be well weighed down in order to prevent further distortion.

During a period when the presses were overloaded with this work, the blowpipe was tried and found to accomplish a more satisfactory job in 4 hours. Although stress-relieving in the furnace was also necessary after oxy-acetylene straightening, it was found much easier to keep the piece straight. This particular casting was out of line about $^3/_8$ inch and was brought back to within $^1/_{16}$ inch of being true.

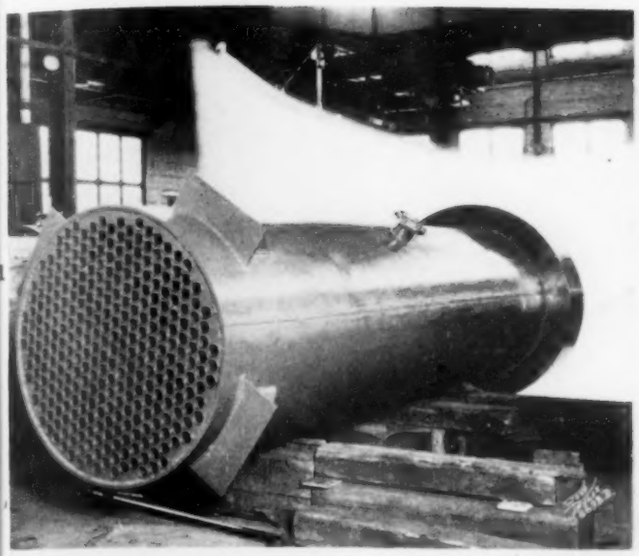
WHAT WELDING HAS DONE for the Refrigerating Industry*

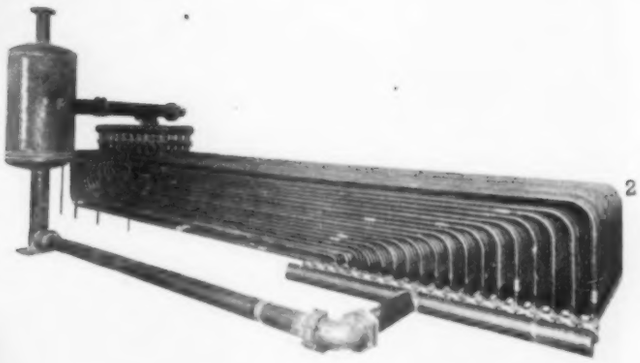
By EMIL A. BEHLING†

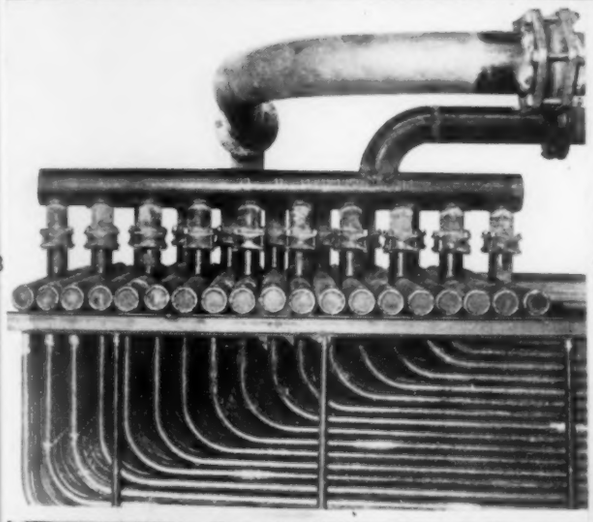
ALTHOUGH it would be generally conceded that the refrigerating industry is important to modern life, it may be of interest to present briefly some of the facts. While food, clothing and shelter are prime essentials for every-day existence, our food, of course, is the most important necessity. Its preservation is essential to health and life itself. But refrigeration plays an important part also in the preservation and conditioning of clothing, furs and other items of apparel. More and more is air-conditioning becoming an essential factor in business offices, theaters, railway passenger cars, stores, hospitals and homes. Refrigeration in various applications is applied in tanneries, in processing petroleum products and in the manufacture of photo films, cellophane and wax paper products. These are only a few of many uses.

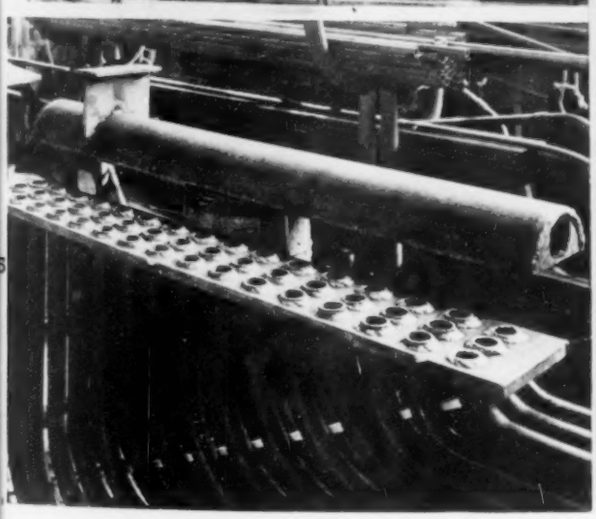
Mechanical or chemical refrigeration, of course, is one of the many benefits to mankind that have followed the development of steam power beginning in the eighteenth

* Presented at Nineteenth Annual Meeting of the AMERICAN WELDING SOCIETY, Detroit, Michigan, October 16–21, 1938.
† Superintendent of Vilter Mfg. Co., Milwaukee, Wis.









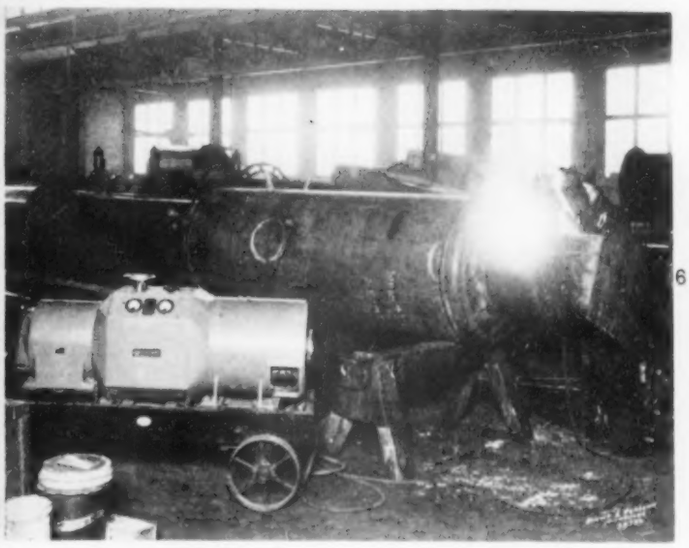


Fig. 1—A Shell-and-Tube Condenser, 48-Inch Shell, 16 Feet Long with Welded Longitudinal Seam, Tube Sheets, Pipe Nozzles Supporting Brackets and Water Chamber

Fig. 2—A Super-Flooded Brine Tank Coil with Sectional Coils Closely Spaced and Welded Into 3-Inch Pipe Headers, the Assembly of Nineteen Coils Each Thirty-Two Pipes Wide, Comprising 7000 Lineal Feet of $1^1/_4$-Inch Pipe

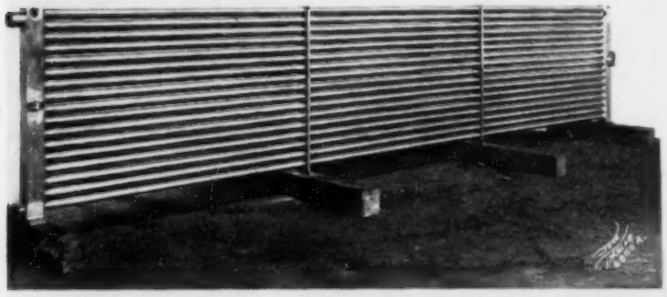
Fig. 3—A Close-up of the Header Assembly and Gives an Idea of the Compactness of Design Made Possible by Welding

Fig. 4—A Similar Assembly in Outline but of Different Welded Construction. Narrow Tube Sheets 7 Inches Wide Provide for Three Rows of $1^1/_4$-Inch Tubes Welded in. They Are Covered by Half of a 7-Inch Pipe Welded to the Tube Sheet at the Sides and Ends to Form a Header

Fig. 5—The Tube Sheet and Tube Ends Welded in Place; Also the Half of a 7-Inch Pipe Ready for Assembly Over the Tube Sheet to Be Welded to It

Fig. 6—A 24-Inch Diameter Vertical Accumulator 10 Feet High Used with the Super-Flooded Coils, in Process of Being Arc Welded. The General Appearance of the Finished Assembly Is Shown in Fig. 2

century and reaching a high point in this era. The ancients as well as the moderns utilized caves, cellars, wells, spring-houses and natural ice for domestic preservation of food supplies. It was not until about 1845 that



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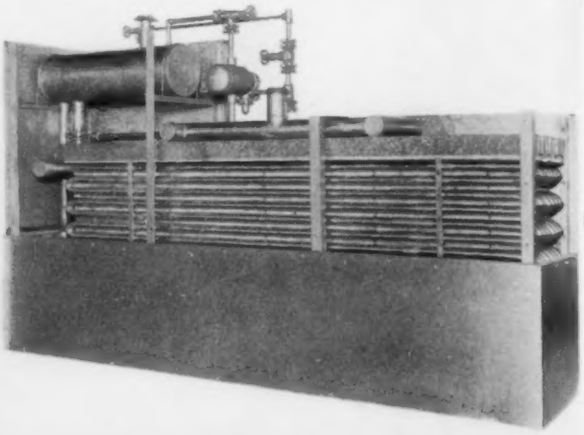

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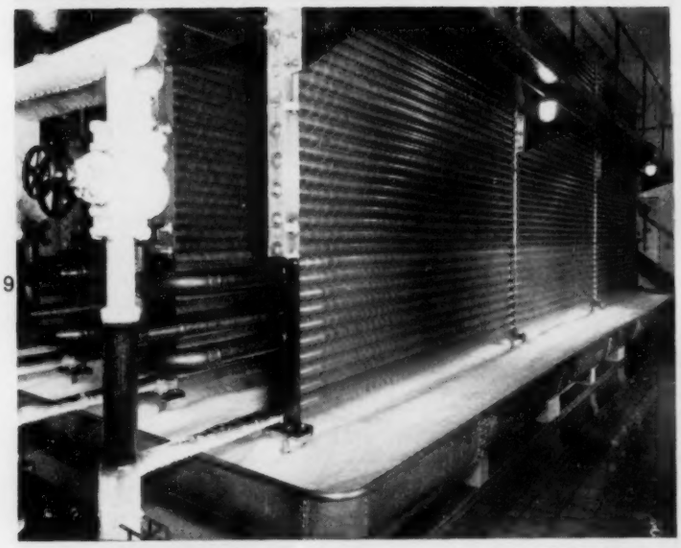

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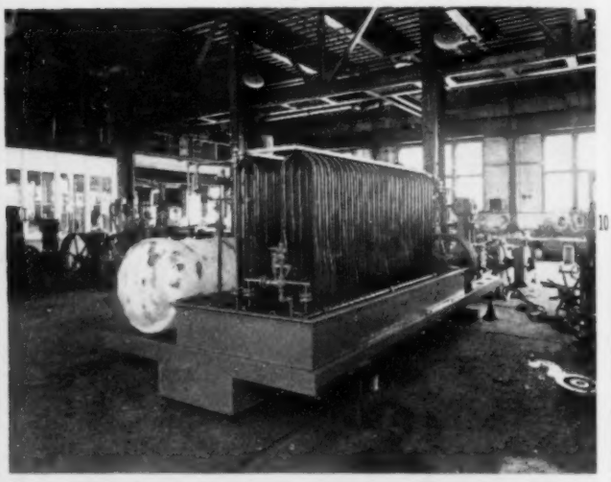

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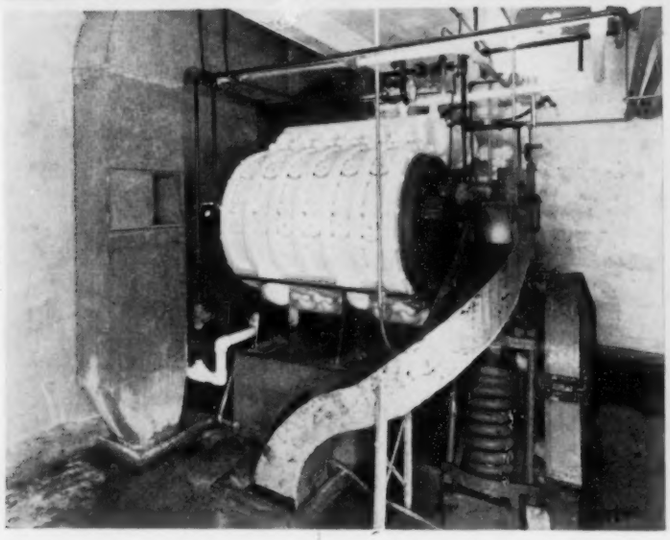

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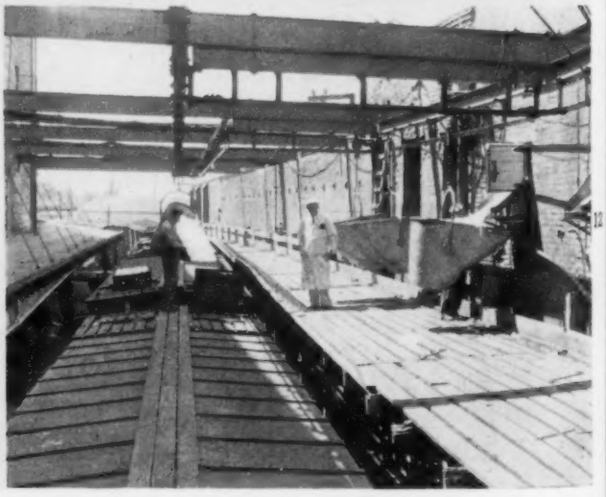

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Fig. 7—A Hot-Wort Cooler Section Made of 16-Gage Stainless Steel Tubing 30 Feet Long, Welded Into Stainless Steel Headers. The Tubes Are Pear-Shaped in Cross Section and Are Assembled in a 1/2-Inch Stainless Steel Tube Sheet Perforated with Pear-Shaped Holes to Fit the Tubes. The Welding Is Done on the Ends of the Tubes, and Then the Header Box Section Is Completed by Welding the Side, Face and End Plates in Place

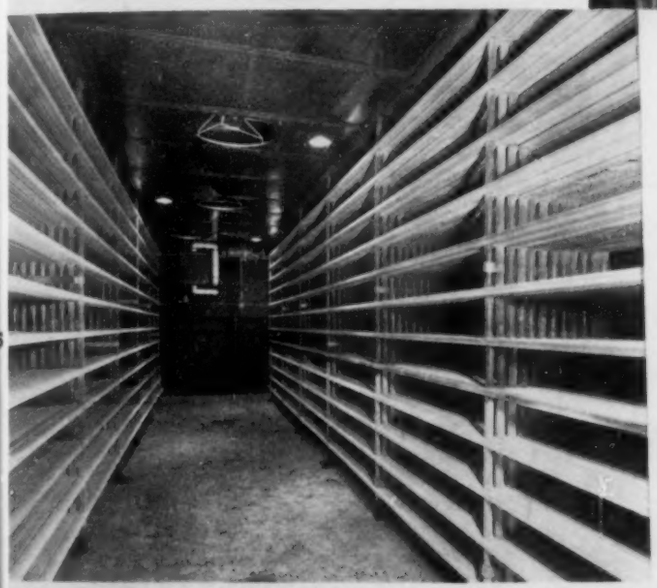
Fig. 8—A Sweet Water-Cooler Which Provides Cold Water for Bandelot Type Milk Coolers in Dairies. The Pipes Are Joined by Welds Made in the Bent Sections. These Originally Were Bent on 8-Inch Centers and Then Cut and Milled to 3 1/2-Inch Centers to Make the Welded Joints. The Whole Upper Assembly Including the Headers, Coils and Accumulator Are Welded, and Then Galvanized. The Tank Is of Welded Construction and the Inside Is Metal Sprayed with Zinc

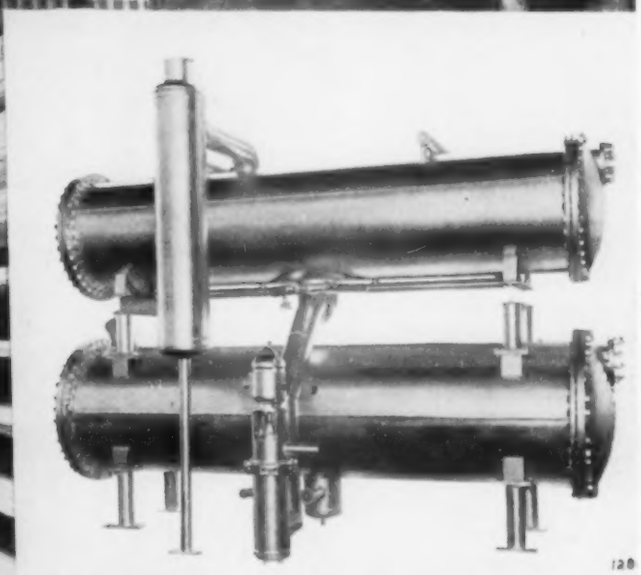
Fig. 9—The Assembly of the Stainless Steel Section Cooled with Ammonia at the Bottom and the Water-Cooled Copper Sections Above, with the Wort at 180° F at the Top Flowing Smoothly Downward and Being Cooled at the Bottom to About 42° F

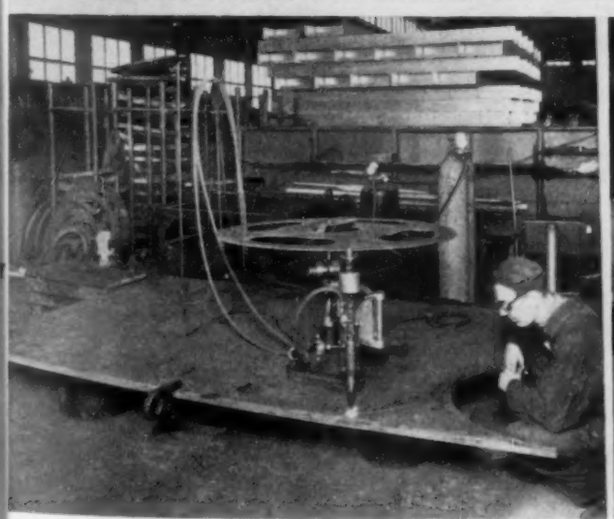
Fig. 10—A Portable Refrigerator Car Pre-Cooler Unit on the Welded Chassis of a Trailer Consisting of a 6 1/2-Inch by 6 1/2-Inch Vilter Compressor, a Vilter-Guild Atmospheric Evaporative Condenser, and a Shell-and-Tube Cooler, All Mounted on One Base. The Particular Advantage Is That It Can Be Moved to Various Points for Railway Car Cooling Where It Would Not Pay to Install a Large Pre-Cooling Plant

Fig. 11—Another Type of Refrigerating Equipment for Car Cooling That Makes Ice Briquettes, Having a Capacity of 30 Tons in Twenty-Four Hours and Requiring Only One-Tenth the Floor Space of a Can Type Ice Plant. Top and Bottom Headers Are Completely Welded as Are the Float Valve and Accumulator

Fig. 12—The Handling of Ice Briquettes from Hoppers to the Cars







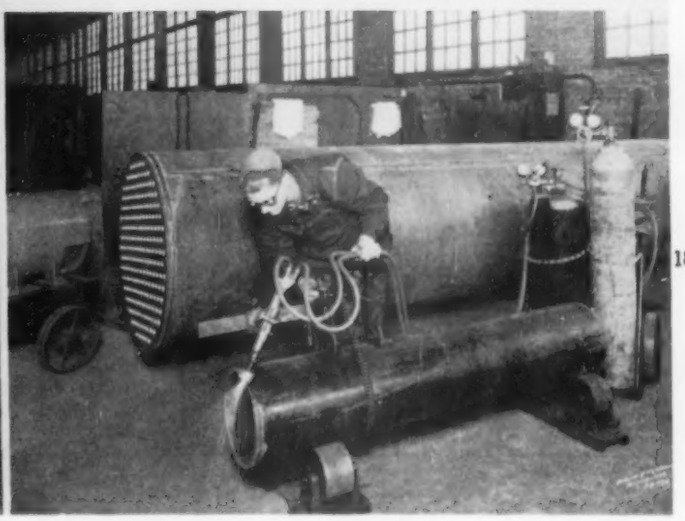


Fig. 13—A Pak-Ice Freezer of Five Tons Daily Capacity, Containing 108 Feet of Square Aluminum Tubing. Made of Four Sections 1 1/2-Inches Square, 26 Feet Long Butt Welded with Oxyhydrogen and Then Coiled as Shown. The Aluminum Framework Was Torch Welded

Fig. 14—The Vilter-Guild Verti-Bay Coils Welded, the Vertical Bays Providing Sections for Strawberry, Vanilla and Other Varieties of Ice-Cream Which Are Hardened at About −25° F.

Fig. 15—A Vilter High-Economy Shelf Coil Made of Rectangular Steel Tubing Welded. The Flat Surface Forms Efficient Contact with Meat Pans. The Room Attains a Temperature of −40° F. The Room Contains 10,000 Feet of 1 1/2 by 2 1/2 Inch Rectangular Pipe in Twenty-Four Coils. Each Coil Is 10 Feet, 10 Inches High and 30 Feet Long

Fig. 16—A Shell-and-Tube Freon Water-Cooler and Condenser with Welded Shells for Air Conditioner Unit in Oklahoma State Buildings, Oklahoma City. Note the Fabricated and Welded Supports as Well as the Girth and Longitudinal Seam Welds

Fig. 17—Cutting a 42-Inch Tube Sheet with the Camograph

Fig. 18—Beveling the End of a 16-Inch Pipe for a Butt Weld

a Dr. Gorrie of New Orleans is alleged to have built an air machine in which compressed air was expanded and thus made to exert a cooling effect, that any serious attempt appears to have been made to utilize mechanical power for cooling. A later development of compressed air for refrigeration was Allen's "dense air" machines used on cargo and passenger ships to some extent at the turn of the century.

Ammonia gas was found, of course, to be more practicable and efficient for the larger refrigerating installations in breweries, packing-houses, cold-storage warehouses and artificial ice-plants, and it remained the principal refrigerant until recent years. Sulphur-dioxide and CO_2 are also used, the former having been employed widely for domestic refrigeration partly because the compression required is of the order of 60 to 70 pounds per square inch. CO_2, a non-toxic gas on the other hand, requires a high working pressure of over one thousand pounds per square inch. Compression pressure required for ammonia is about 165 to 175 pounds. Within a few years a new refrigerating agent has come into use called Freon or F_{12} (difluoro-dichloro-methane) that seems to be rapidly displacing those refrigerants used before because it is odorless, tasteless and non-poisonous. The working pressure required is about 100 pounds per square inch.

All these and other chemicals used for modern refrigerants are very penetrating, and it is of the utmost importance that the system be hermetically sealed and that no mechanical joints exist except those necessary for inspection, cleaning and repairs. The answer to this desirable requirement was the modern welding processes. The company with which the author is associated was one of the first to adopt electric and gas welding in the manufacture of condensers, brine coolers, accumulators, headers, high-pressure oil separators, liquid receivers, super-flooded coils and pipe lines. Before the adoption of welding the construction of these parts was limited by trouble experienced with castings and leaky joints, and also by awkward assemblies due to screwed joints.

The start of our welding on low-pressure pipe coils for ice tanks was made on a Thompson butt welder in 1906. Gas welding was introduced to the plant in 1907, and oxyhydrogen torch cutting in 1908 and 1909. Headers and receivers were gas welded in 1911. Electric arc welding was introduced in 1913. In that year we electric welded headers and receivers. In 1925 the company discontinued pipe coils and condensers, changing over to shell-and-tube condensers and brine coolers.

Shell-and-tube condensers range from 8 inches to 60 inches in diameter. The 8-inch to 26-inch condensers and coolers have pipe shells. Wall thickness of the shells runs from $^3/_8$ inch to 1 inch. Shells larger than 26 inches in diameter are made of steel plates formed to circular shape and welded longitudinally with double-vee joints conforming to the A. S. M. E. and National Board codes for unfired pressure vessels.

In 1925 we went into a new field for the use of welding when starting to manufacture brine coolers, shell-and-tube condensers and heat exchangers. Our brine coolers and condensers are cylindrical shells 16 inches to 60 inches in diameter with wall thickness ranging from $^3/_8$ to 1 inch and with tube sheets at each end $1^1/_4$ inches thick. These tube sheets are drilled and grooved with a roller tool for the tubes. With the exception of the mechanical rolling in of the tubes, the whole construction is made up entirely by electric welding including the longitudinal seams running the full length of the shells. These changes eliminated pipe coils with semi-steel return bends.

From this date, say 1925, on down to the present has been a period of expanding uses of welding and cutting for fabrication. The cutting torch is comparable to the tailor's shears with which the "cloth" is cut to sizes and shapes required. Our first cutting for welded assemblies was done with the hand torch guided by a radius rod and revolving the torch around a center point to make tube sheets for condensers and brine coolers. These plates prior to 1929 had been bought sheared to shape at the steel mills. The sheared plates were of irregular contour and warped which necessitated machining in a lathe to make them round and flat. In 1930 we started cutting tube sheets and flanges with a Camograph. Steel flanges for welding are cut from steel plates replacing the semi-steel castings used theretofore on pipe from $3^1/_2$ inches to 16 inches in diameter. These flange circles are cut from rolled steel plates 72 inches by 20 feet, and range from 8 inches to 72 inches in diameter, the thickness for tube sheets ranging from $^3/_4$ inch to $1^3/_4$ inches.

Beveling of pipe and shells for welding to tube sheets was formerly done by cutting to length and then sending the lengths to the machine shop to be beveled in a lathe to an angle of 30 degrees to provide for single-V welds. This beveling is now done with a pipe beveling machine torch on all sizes from 6 inches to 50 inches in diameter and thicknesses of from $^1/_4$ inch to 1 inch.

Not only have welding and cutting made refrigerating machinery and equipment more simple and dependable, but they have reduced costs and made new designs possible and practicable as we shall see in the photos chosen to illustrate examples of such welded fabrications.

Brazing the tubes into the tube sheets of condensers and coolers which may be practicable with Freon although not so with ammonia will be a next step in the process of making refrigerator units hermetically and permanently sealed vessels from which the escape of the refrigerant is entirely eliminated.

In conclusion, two views of cutting equipment are included, showing the camograph cutting a circular tube sheet 42 inches in diameter, Figs. 17 and 18 showing the pipe beveling machine trimming the end of a 16-inch pipe for a butt weld.

MARSH BUGGY

Now, there is something entirely new in the "marsh buggy" line!

Instead of pneumatic rubber tires, the newest "marsh buggy" is built of arc welded steel throughout, even to the tires! The tires are large arc-welded steel drums. They are buoyant because of their leak-proof arc-welded construction.

On water, marsh or highway, the "marsh buggy" as pictured here, is capable of carrying a 6000-pound load. This is possible because the all arc-welded unit is so constructed that it will both float on water and operate on land.

The complete "buggy" weighs 10,000 pounds and measures 21 feet in length and 15 feet in width over-all. The wheels which are seven feet in diameter and four feet wide, are of an air tight construction making it possible for the unit to float. The entire machine is welded.

The unit is powered by a Lincoln Zephyr Engine which gives an operating speed of 2 miles per hour in water, 7 miles per hour in marsh and 12 miles per hour on the highway.

This "marsh buggy" was constructed by the Stanolind Oil and Gas Company in their Dallas, Texas, shop and is to be used for transportation and exploration work in marshy sections.

WELDED JOINTS IN Carbon-Molybdenum Piping*

By R. W. CLARK†

THE comparatively recent increase of steam temperatures and pressures in modern power stations has placed much more rigid requirements on joints in piping for this service.

Carbon-molybdenum steel, because of its good physical properties and resistance to creep at high temperature, has been generally accepted as the base material for the pipe, and welding as the most satisfactory method of joining it. However, there are differences of opinion regarding groove design, detailed welding procedure, methods of inspection and heat treatment subsequent to welding of joints for this service.

The first series of tests was made to determine:

1. The effect of groove design, by comparing four representative types.
2. Whether or not general chipping of each bead is necessary.
3. The value of a recording voltmeter as a means of checking soundness of welded joints.

The second series was made to determine the residual stresses in pipe joints welded at three different temperatures when tested in the "as-welded," "furnace stress-relieved" and "local stress-relieved" condition.

FIRST SERIES OF TESTS

Before starting this series of tests, preliminary samples in both plate and pipe were made to establish the welding procedure for various types of grooves in pipe in the horizontal and vertical positions.

* Paper presented at Annual Meeting, A. W. S., Oct. 16 to 21, 1938.
† Works Laboratory, General Electric Company, Schenectady.

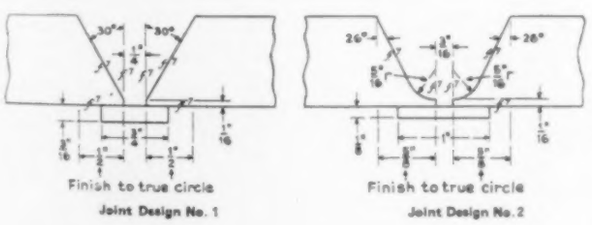
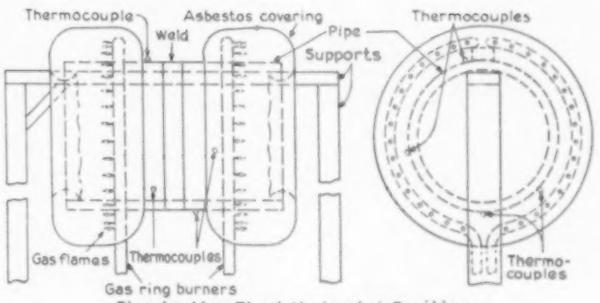
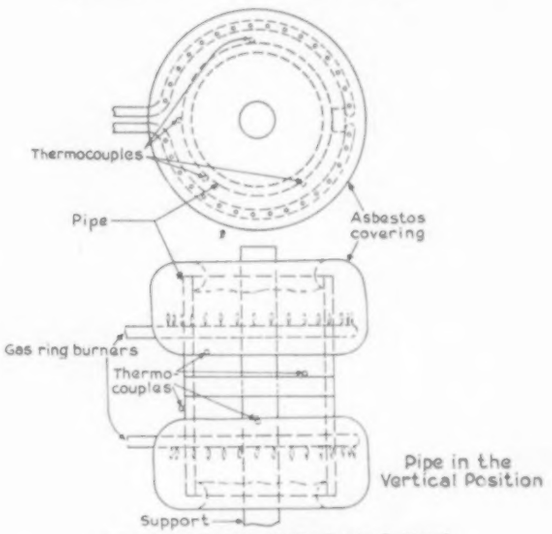


Fig. 1
Four Types of Grooves Compared



Pipe in the Fixed Horizontal Position



Sketch of Pipes Set Up for Welding Showing Position of Gas Heating Apparatus and Thermocouples

Fig. 2

All welded pipe samples were taken from one length of $7\frac{5}{16}$ inch I.D. and $8\frac{5}{8}$ inch O.D. seamless tubing, its composition being 0.13% carbon, 0.50% molybdenum. All position 0.50% molybdenum electrodes of $\frac{1}{8}$ inch and $\frac{5}{32}$ inch diameter were used throughout. When welded the pipe samples were approximately 30 inches long.

The inside diameter of each set of pipes was machined at the joint just enough to provide a proper fit for the backing rings. Pipe ends were not bumped up and no recess was made for the backing rings on any of the joints because:

1. Such preparation would materially interfere with the making of reduced section tensile, and face and root bend specimens which would give comparative data on the respective joints.
2. This preparation does not have a definite bearing on the weldability of the joint.

For each of the four groove designs used, one pipe was welded in the fixed horizontal and one in the vertical position. The details of the four groove designs are shown in Fig. 1.

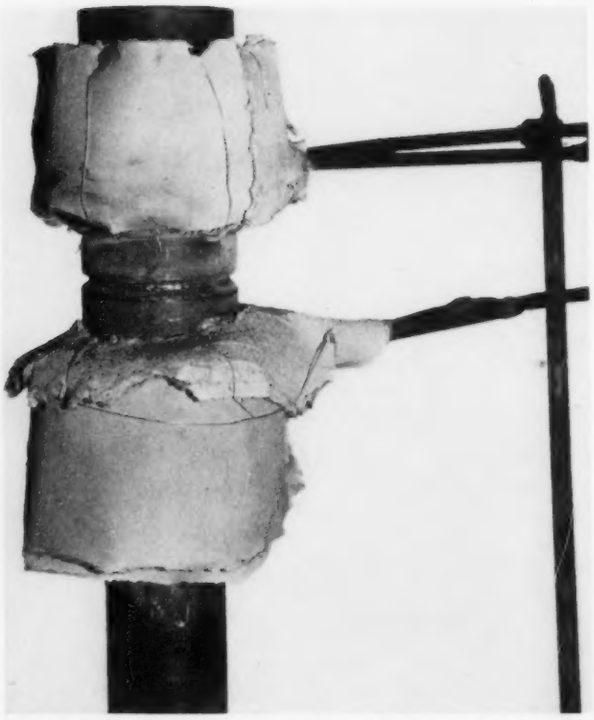


Fig. 3—Pipe Set Up in Vertical Position and Partly Arc Welded. View Showing Asbestos Covering and Gas Supply Lines to Ring Burners Used to Heat and to Maintain Desired Temperature During Welding Operation

All welds were made in the shop by a production welding operator. The pipe set-up, method of preheating and concurrent heating and welding conditions were typical of shop production conditions. The preheating and concurrent heating gas burner rings and the thermocouples were located as shown in Fig. 2. A pipe in the vertical position partially welded with gas burner rings covered with asbestos is shown in Fig. 3.

Each pipe sample was heated slowly to approximately 500° F. and held there until the joint was completely welded. Each bead was cleaned with a small air operated cleaning tool and hand wire brush before depositing the next bead. Care was taken to insure that each bead was of the proper shape, and in the proper location and that craters were properly filled when the arc was broken for electrode changes. Figure 4 shows location and shape of beads but in actual pipe welding each bead is completed before next bead is started. General chipping of each bead and of craters was not employed. After welding, the pipe sample was covered with asbestos and allowed to cool slowly to room temperature. The welding procedure for each welded joint was as shown in Fig. 5. A recording voltmeter was used throughout the entire welding of samples. Figures 6 and 7 show typical arc voltage records of first and second beads on fixed horizontal and vertical pipe samples.

Radiographs of three sections of each welded joint were taken. Figure 8 shows a representative radiograph.

Each sample was locally stress relief annealed by the induction method within a temperature range of 1100 to 1200° F. for 1 hour.

From each pipe sample, three reduced section tensile, three face bend and three root bend specimens were saw cut, machined and tested. At least 3 representative macro-sections of the joint were taken from each pipe sample. These macro-sections were also used for hard-

Fig. 4—Two Pipe Joints Welded to Show Location and Shape of Each Bead

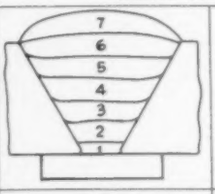
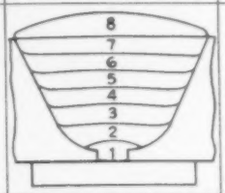
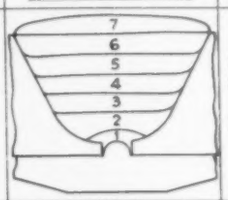
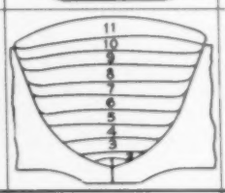
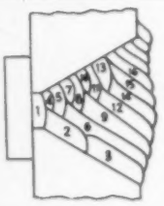
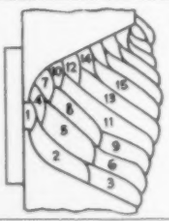
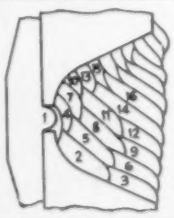
Fixed Position of Pipe	Pipe Joint No.	Joint Design	Direction of Welding	WELDING PROCEDURE: Electrode Manipulation	Type, Position, Thickness, and Number of Beads		Size of Electrode	Avg. Current and Arc Voltage: 1/8 in Diam Elec	Avg. Current and Arc Voltage: 5/32 in Diam Elec	Nature of Cleaning
HORIZONTAL	S51-C-12	No. 1	Bottom to Top	A whipping action was used in depositing the 1st bead. On all other beads a pool of molten metal was carried and a weaving motion was used.		1. All weave beads 2. Avg. thickness 5/32" - 3. Total No. beads 7	Beads 1 & 2 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-26 volts	105-125 amps 23-28 volts	Small air hammer with detachable chisel
	S51-C-13	No. 2	Bottom to Top	Same as S51-C-12 Joint Design No. 1		1. All weave beads 2. Avg. thickness 1/8" - 3. Total No. beads 8	Bead 1 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-26 volts	105-130 amps 23-28 volts	Small air hammer with detachable chisel
	S51-C-17	No. 3	Bottom to Top	Same as S51-C-12 Joint Design No. 1		1. All weave beads 2. Avg. thickness 5/32" - 3. Total No. beads 7	Beads 1 & 2 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-25 volts	105-130 amps 23-28 volts	Small air hammer with detachable chisel
	S51-C-18	No. 4	Bottom to Top	Same as S51-C-12 except that whipping was necessary on the first three beads		1. All weave beads 2. Avg. thickness 1/8" 3. Total No. beads 11	Beads 1,2&3 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-25 volts	105-130 amps 23-28 volts	Small air hammer with detachable chisel
VERTICAL	S51-C-14	No. 1	Counter Clockwise	A pool of molten metal was carried fairly continuously. In depositing the string beads in the corners, no weaving was possible. In depositing the wider weave beads, a weaving motion was used.		1. Combination of weave and "string beads. 2. Thickness Weave beads 5/32" - String beads 5/32" 3. Total No. beads 20	Beads 1,4&7 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-26 volts	105-125 amps 23-28 volts	Small air hammer with detachable chisel
	S51-C-15	No. 2	Counter Clockwise	Same as S51-C-14 Joint Design No. 1		1. Combination of weave and "string beads 2. Thickness Weave beads 5/32" - String beads 5/32" 3. Total No. beads 24	Bead 1 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-25 volts	105-130 amps 23-28 volts	Small air hammer with detachable chisel
	S51-C-16	No. 3	Counter Clockwise	Same as S51-C-14 Joint Design No. 1		1. Combination of weave and "string" beads 2. Thickness Weave beads 5/32" - String beads 5/32" 3. Total No. beads 25	All beads 5/32" diam elec	80-100 amps 22-25 volts	105-130 amps 23-28 volts	Power brush
	S51-C-19	No. 4	Counter Clockwise	Same as S51-C-14 Joint Design No. 1		1. Combination of weave and "string" beads 2. Thickness Weave beads 5/32" - String beads 5/32" 3. Total No. beads 28	Beads 1,2&3 1/8" diam elec Other beads 5/32" diam elec	80-100 amps 22-25 volts	105-130 amps 23-28 volts	Small air hammer with detachable chisel

Fig. 5—Summary of Welding Procedure for Each Joint Welded

ness determinations. Figure 9 shows specimens from pipe welded in the fixed horizontal position after testing. Figure 10 shows photomacrographs of cross sections of the two welded pipes with hardness values (Rockwell "B") and representative photomicrographs.

RESULTS

Examination of radiographs, macro-sections, physical test results and observations during welding show that sound welded joints were made with all four types of groove designs.

Test results indicate that, with the welding procedure and groove designs used, general chipping of each bead and of craters was not necessary.

In comparing test results with the recording voltmeter records, no defects were found corresponding to the irregularities in the arc voltage records.

These tests substantiate our welding experience with regard to the procedure for insuring satisfactory welded joints in any structure which is as follows:

1. Establish and qualify the procedure.
2. Qualify the operator under the procedure.
3. Properly supervise and inspect visually during welding.

The use of non-destructive tests on completed production welds as a substitute for the above procedure will prove that the above procedure is the most economical and practical when applied before starting production welding.

SECOND SERIES OF TESTS

Difficulties in welding, such as cracking and distortion are usually associated with thermal stresses resulting from the sharp temperature gradient between the molten weld metal and the adjacent base metal.

Creep tests by the relaxation method have demonstrated that holding this material at 1100 to 1200° F. for 1 hour per inch of thickness will greatly reduce the residual internal stresses.

By preheating and concurrent heating to a temperature of 300 to 500° F., the temperature gradient is less than when welding with the base metal at room temperature or below. It is logical to assume that with the lower temperature gradient, the magnitude and concentration of residual stresses will be less.

Experience has shown that preheating and concurrent heating is one of the best preventatives against cracking while stress relief annealing will not remove cracks once they are there. Preheating and concurrent heating have been found very beneficial in the development of welding procedures involving relatively thick sections, rigid structures, alloy steels and when welding structures in cold weather.

It is also possible that the residual stresses in a structure welded at the proper preheat and concurrent heating temperatures will be low enough so that stress-relief annealing will be unnecessary. However, unless definite data are available, when in doubt it is wise to play safe by preheating concurrent heating and also stress-relief annealing.

The first series of tests showed that a preheating and concurrent heating temperature of 500° F. produced satisfactory results as far as room temperature, physical properties and soundness are concerned, but gave no information concerning residual stress.

The second series of tests, which were really pilot tests, was made to determine the residual stresses in

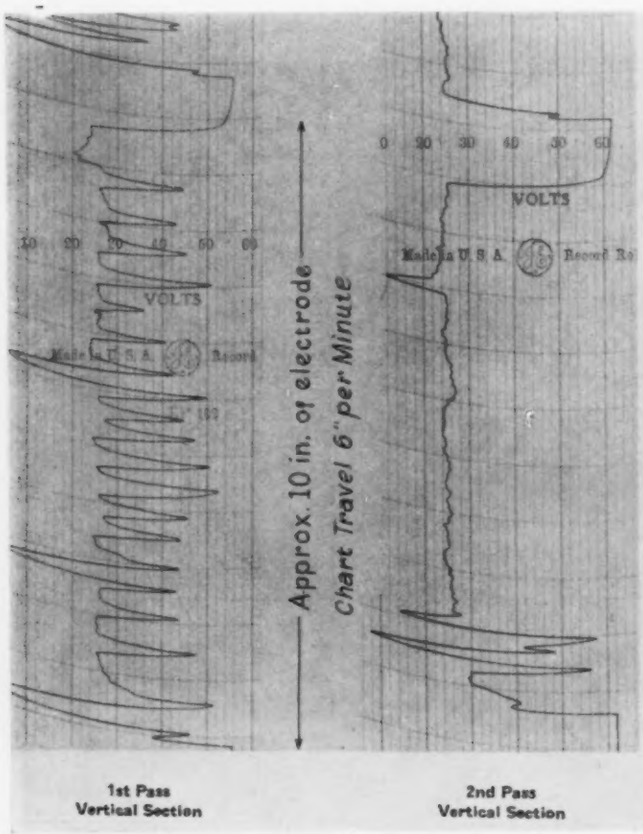


Fig. 6—Typical Arc Voltage Record, Pipe Position Horizontal

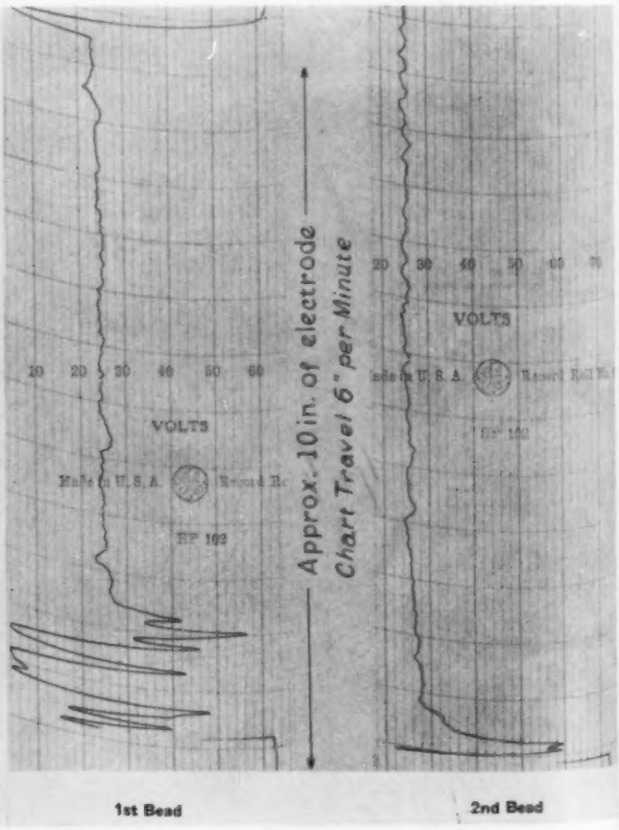


Fig. 7—Typical Arc Voltage Record, Pipe Position Vertical

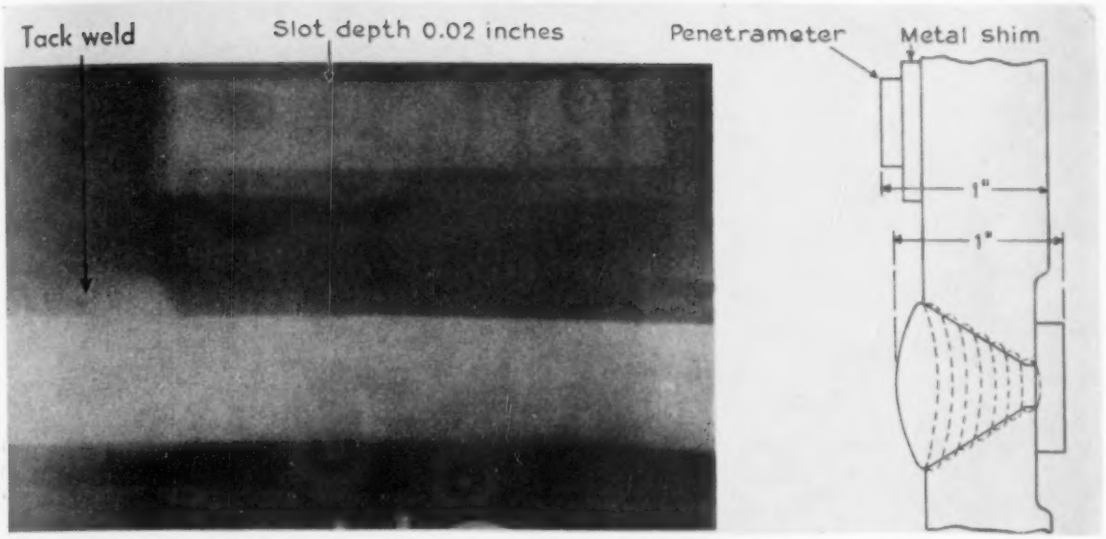


Fig. 8—Reproduction of Radiograph of Vertical Welded Section of Fixed Horizontal Pipe

samples welded at three preheat temperatures when tested in (*a*) the "as-welded" condition; (*b*) after stress relieving in a furnace; and (*c*) after local stress-relief annealing.

All pipe samples in this series were welded with the pipe in the vertical position because in this position a larger number of beads is required than when welding pipe in the horizontal position, with resulting higher residual stresses. The groove design used was Design No. 1 in Fig. 1 with the same welding conditions and procedure as in the first series, except for preheating and concurrent heating temperatures. Pipe sizes and composition were the same as in first series.

There were seven pipe samples; one without a weld, one welded at room temperature, one at 300° F. and four welded at 500° F. After welding, samples were radiographed.

Pipe samples S17-C13, 14 and 15, and S17-B16 which were 16 inches long when welded were machined as follows:

The pipe samples were cut to a length of 15 inches and the ends were squared. Then they were laid out and the location of all specimens was properly marked.

Each sample was set in a boring mill, centered and six circumferential grooves, $\frac{1}{2}$ inch wide, were machined just deep enough to clean up the surface. These grooves, shown in Fig. 11, provided location and satisfactory surface for measuring diameters. The diameters were measured and recorded at each groove and at the locations in each groove where longitudinal specimens were

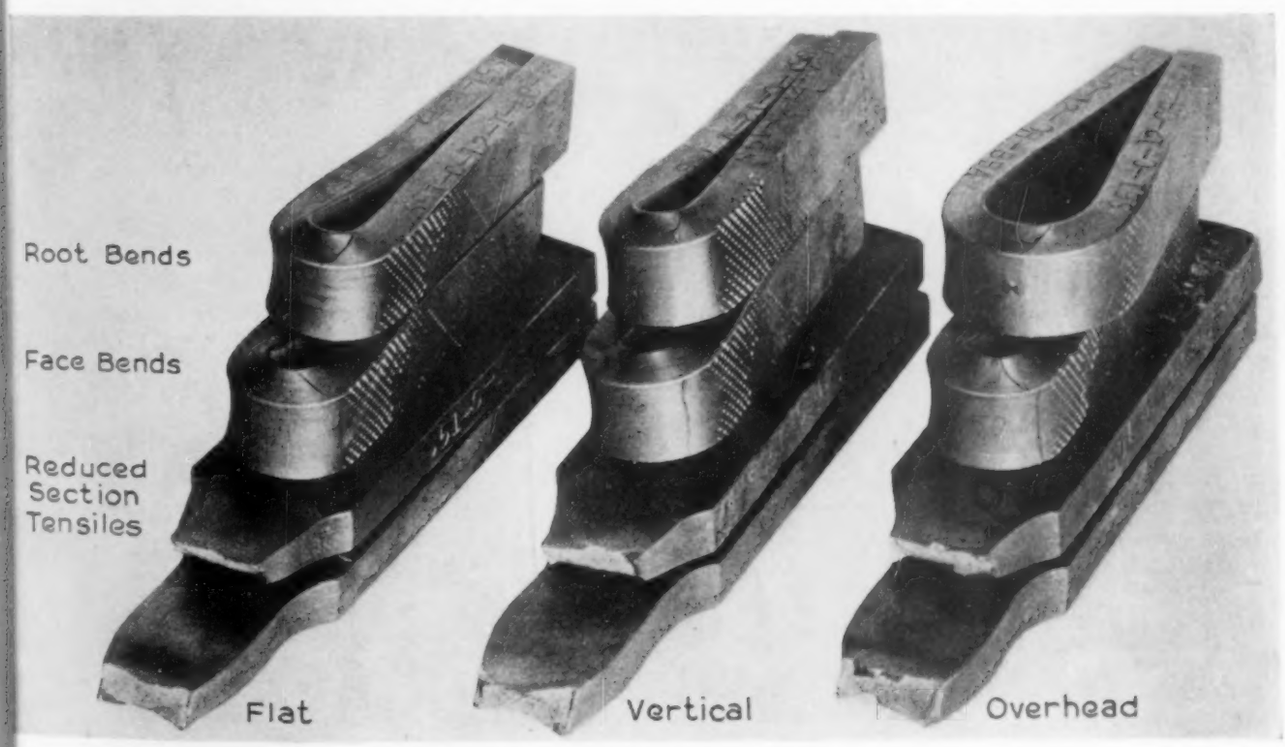


Fig. 9—Typical Welded Specimens After Testing

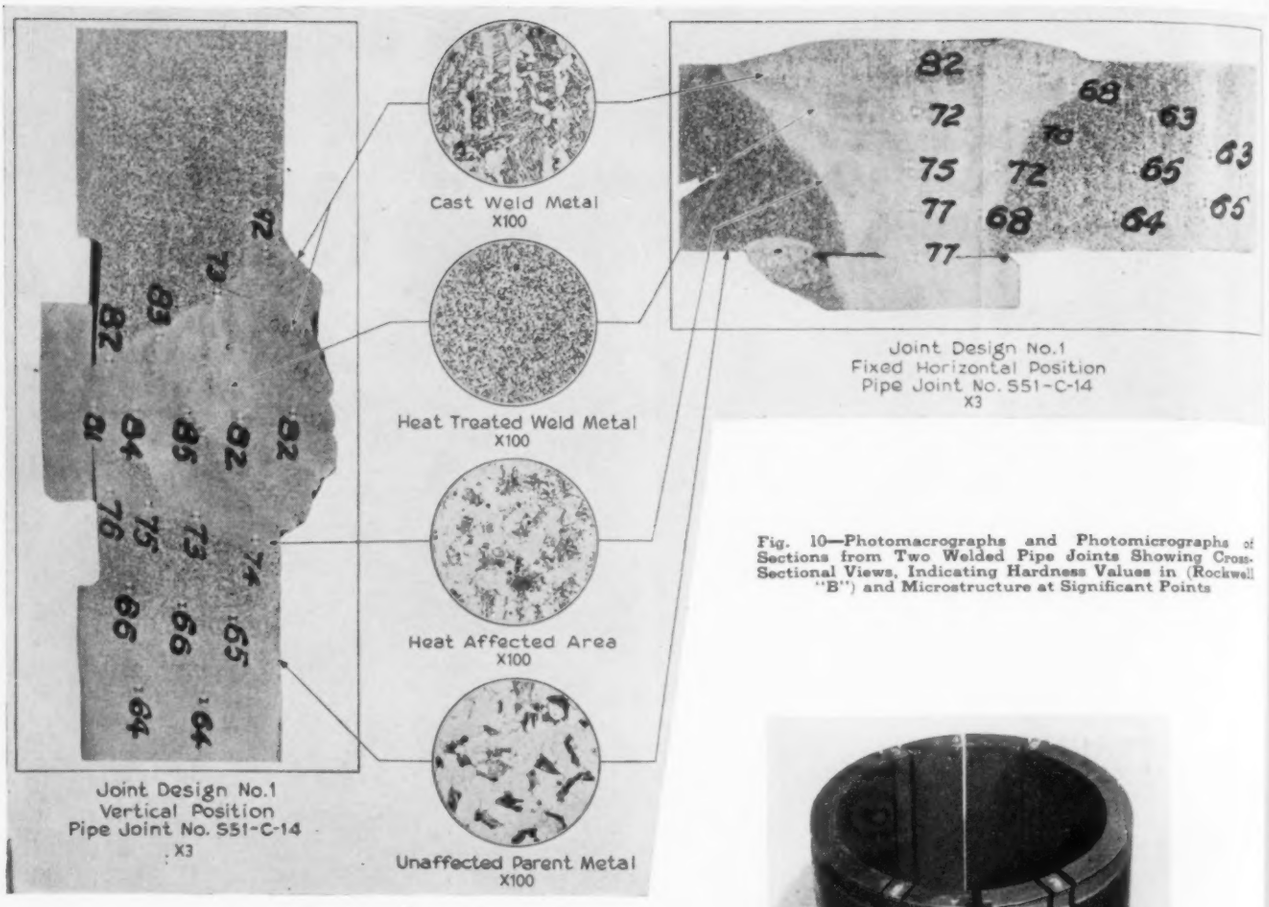


Fig. 10—Photomacrographs and Photomicrographs of Sections from Two Welded Pipe Joints Showing Cross-Sectional Views, Indicating Hardness Values in (Rockwell "B") and Microstructure at Significant Points

to be removed later. Next, samples were set up in a milling machine and a groove, $^1/_4$ inch deep and $^1/_2$ inch wide, was milled the full length. The width of this groove was measured and recorded at 7 points. The pipes were then split by saw cutting through center of longitudinal groove. The width of longitudinal groove was measured again at the same 7 locations.

Each pipe was then cut in halves longitudinally, by saw cutting "*F*" in Fig. 11. One-half of each pipe was then stress-relief annealed at 1100° F. in a furnace. Two longitudinal specimens $^1/_2$ inch wide were removed by saw cutting from each half of each pipe sample as shown in Fig. 12.

Each longitudinal specimen was set up in a jig (Fig. 13) and measured at six points to determine the deflection at

Fig. 11—Welded Pipe Sample Used for Checking Residual Strains. View Showing Sample with Parts Laid Out and Partly Machined

Fig. 12—Welded Pipe Sample Used for Checking Residual Strains. View Showing Sample Completely Machined and Relative Positions of Longitudinal Specimens

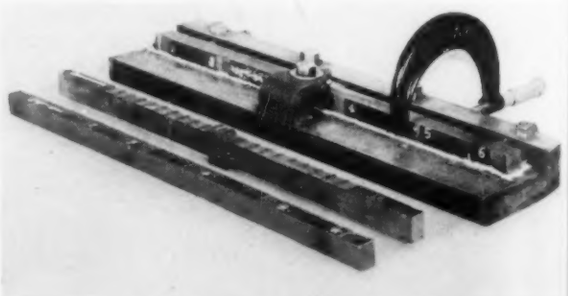


Fig. 13—Longitudinal Specimen from Arc-Welded Pipe Sample, Located in Jig for Measuring Deformation to Check Residual Strains. Specimen in Foreground Is from Unwelded Pipe and Other Is from Welded Pipe

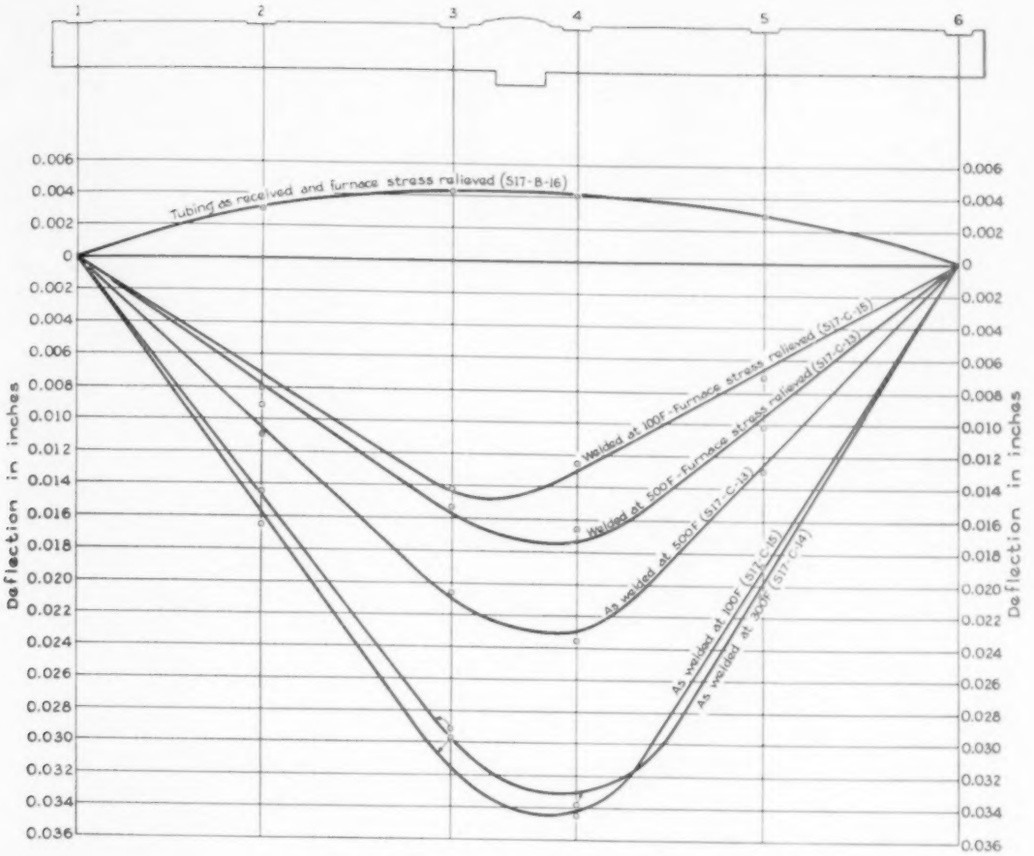


Chart showing deflection curves of strips cut from pipes

Fig. 14

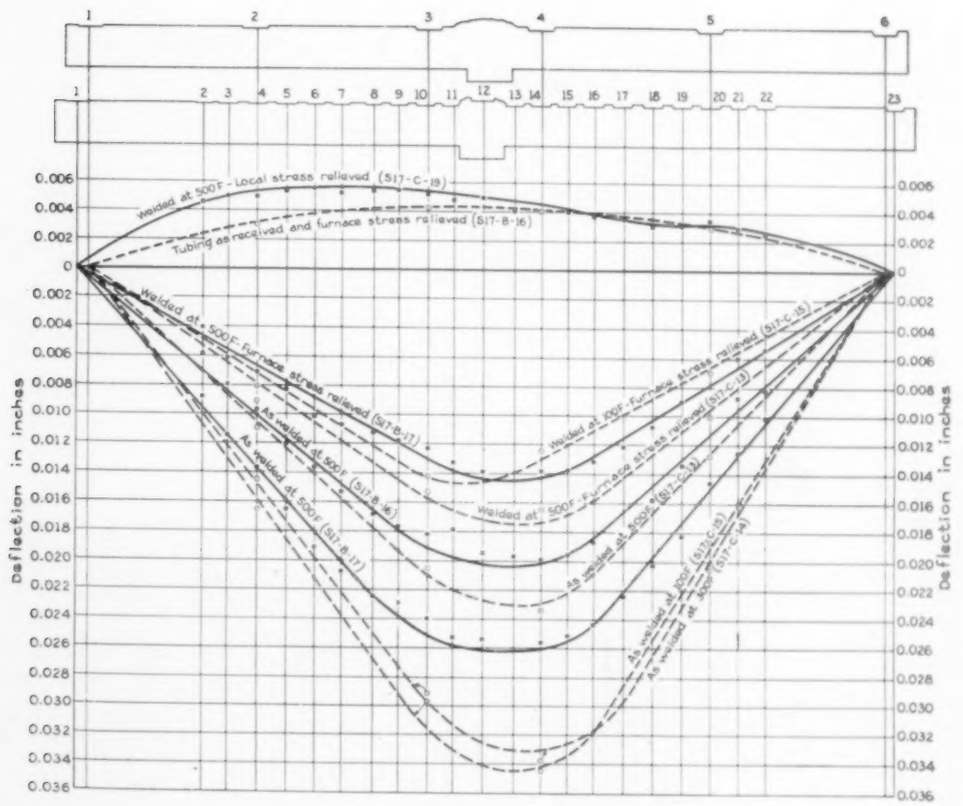


Chart showing deflection curves of strips cut from pipes

Fig. 15

each point with reference to its original position as determined by the original diameter measurements.

The measurements of deflection of the longitudinal specimens are shown in Fig. 14. These measurements show the most deflection for the pipe welded at room temperature and tested in the "as-welded" condition and a decreasing amount as the preheating temperature was increased.

The effect of furnace stress relieving was the greatest on specimens welded at room temperature and the least on specimens welded at 500° F.

The trend of results obtained by measuring the movement of the pipe after cutting through the wall longitudinally is the same as the trend of deflection measurements on the longitudinal specimens. All of the welded pipe samples opened up when split longitudinally in the "as-welded" condition by the following amounts:

S17-C-15 0.09 inch open on pipe welded at room temperature
S17-C-14 0.084 " " " " " " 300° F.
S17-C-13 0.04 " " " " " " 500° F.
S17-B-16 { 0.004 " open at one end } on pipe sample
{ 0.008 " closed at other end } without a weld

The results shown in Fig. 15 indicate that the bending took place in a relatively short length at the welded joint but the measurements were not taken close enough together to show the distance through which the bending took place or the shape of the bend.

At this point the last three of the seven pipes were welded at a preheating and concurrent heating temperature of 500° F. The length when welded of these three samples was increased to 30 inches. The only difference in machining these three samples, as compared to the previous four, was an increase in the number of circumferential grooves for measuring diameters and deflections to give more points on the curve to determine the shape of the bend. The length of longitudinal test specimens was still maintained at 15 inches.

S-17-B-17 was a duplicate of S17-B-13 with only two longitudinal specimens in the "as-welded" condition.
S17-B-18 was a check on both S17-B-13 and 17 in the "as-welded" condition but with four longitudinal specimens instead of two.
S17-B-19 was the same as S17-B-18 except that the pipe sample was locally stress-relief annealed giving four longitudinal samples for that condition.

After splitting the pipe samples longitudinally as previously described, it was found that they had opened up the following amounts:

S17-B-17 0.055 inch open-checked in "as-welded" condition.
S17-B-18 0.06 inch open-checked in "as-welded" condition.
S17-B-19 0.015 inch open-checked after local stress relieving.

The measurements of deflection of the longitudinal specimens taken from the seven pipe samples are shown in Fig. 15. The six curves shown by dotted lines are the same curves shown Fig. 14. The four curves shown in solid lines show deflections of the longitudinal strips cut from the last three pipe samples welded. These solid line curves with the greater number of points show more definitely the shape and location of the bending.

Curves for specimens tested in the "as-welded" condition and in the furnace stress-relieved condition are of the same general shape. The curve for specimens welded at room temperature and tested in the "as-welded" condition show the greatest deflection and the sharpest bend. While the three curves for specimens welded at 500° F. and tested in the "as-welded" condition show some variation in the maximum deflection, they have about the same shape and location of bend.

Curves for specimens welded at both 100° F. and 500° F. and furnace stress-relief annealed are nearly identical and show less deflection and bend than similar specimens tested in the "as-welded" condition.

The curve for specimens from the welded pipe after *local* stress-relieving indicates that stress in the area around the weld has been apparently removed. However, the shape of the curve indicates that our specimens were not long enough to give a true picture of the stress condition resulting from the temperature gradients due to local stress-relief annealing.

CURRENT WELDING LITERATURE

Accident Prevention. Safe Practices Return Dividends. Oxy-Acetylene Tips (Oct. 1938), vol. 17, no. 10, pp. 221–226.

Air Compressors. Reconditioning Large Compressor by Oxy-acetylene Welding. Modern Power (Sept. 1938), vol. 32, no. 9, pp. 28–29.

Airplane Manufacture. Welding Aluminum and Its Alloys. Aero Digest (Sept. 1938), vol. 33, no. 3, pp. 58, 61–62 and 92.

Automobile Manufacture. Arc Welding in Automotive Industry, H. D. Doud. Industry & Welding (Oct. 1938), vol. 11, no. 10, pp. 21–22, 24 and 70.

Automobile Manufacture. Welded Construction. Automobile Engr. (Oct. 1938), vol. 28, no. 376, pp. 373–374.

Brazing. Electric-Furnace Brazing in Manufacture of Automobiles, H. M. Webber. Gen. Elec. Rev. (Oct. 1938), vol. 41, no. 10, pp. 442–444.

Bronze Welding of Heavy Castings, C. E. Hook. Industry & Welding (Oct. 1938), vol. 11, no. 10, pp. 25–26 and 28.

Bronze Welding. Paper Mill Saving. Oxy-Acetylene Tips (Oct. 1938), vol. 17, no. 10, p. 228.

Car Building. Arc Welding in Railroad Car Construction, H. S. Card. Iron Age (Aug. 18, 1938), vol. 142, no. 7, pp. 36–37 and 43.

Chemical Equipment. Repairing Worn Chemical Plant Pumps, C. H. S. Tupholme. Indus. Chemist (Sept. 1938), vol. 14, no. 164, pp. 368–369.

Codes. Special Requirements in Building Construction. Industry & Welding (May 1938), vol. 11, no. 4, pp. 13–16.

Copper Welding—Résumé, W. C. Swift. Industry & Welding (Oct. 1938), vol. 11, no. 10, pp. 49–52.

Copper Welding. Methods of Joining Copper Alloy Products. Metal Industry (N. Y.), vol. 35, no. 9 (Sept. 1937) pp. 434–437; no. 10 (Oct.) pp. 498–501; no. 11 (Nov.) pp. 555–556, and vol. 36, no. 1 (Jan. 1938) pp. 6–8; no. 4 (Apr.) pp. 174–176; no. 6 (June) pp. 275–278; no. 8 (Aug.) pp. 382–384; no. 9 (Sept.) pp. 427–429 and no. 10 (Oct.) pp. 472–474.

Cranes, Traveling. Timber Yard Crane. Engineer (Sept. 9, 1938), vol. 166, no. 4313, pp. 288.

Electric Welding, Arc. Cost of Welding and Welded Products, E. W. P. Smith. Iron & Steel Engr. (Aug. 1938), vol. 15, no. 8, pp. 36–43.

Electric Welding, Arc. Economics of Arc Welding, E. W. P. Smith. Metal Progress (Aug. 1938), vol. 34, no. 2, pp. 131–134; see also Iron Age (June 30, 1938), vol. 141, no. 26, pp. 36–38 and vol. 142, no. 3 (July 14) pp. 50–51 and 55.

Electric Welding, Arc. Tentative Specification for Metallic Arc (Iron and Steel) Electrodes for Welded Steel Buildings. Can. Eng. Standards Assn.—Tentative Specification S45T—1938, 19 pp., 50¢.

Electric Welding Arc. Technique of Arc Welding, R. Owens. Welding Engr. (July 1938), vol. 23, no. 7, pp. 29–30.

Electric Welding, Arc. Time Values for Arc Welding, H. F. Jacobsen. Factory Mgmt. & Maintenance (Oct. 1938), vol. 96, no. 10, pp. 87–90.

Electric Welding Machines. Hints on Planning for Arc Welding, E. D. Lacy. Sheet Metal Industries (Sept. 1938), vol. 12, no. 137, pp. 1048 and 1050.

Electric Welding, Resistance. Electronic Control Modernizes Resistance Welding, E. H. Vedder. Welding Engr. (Sept. 1938), vol. 23, no. 9, pp. 31–34.

Ferry Boats, Steam. Michigan State Autoferry "City of Munising." Mar. News (Sept. 1938), vol. 25, no. 4, pp. 21–22.

Gases. Magnaflux Inspection of Gas Cylinders. Iron Age (July 1938), vol. 142, no. 2, p. 49.

Gears and Gearing Manufacture. Torch Hardening Method for Gears, W. E. Sykes. Tool Engr. (Oct. 1938), vol. 7, no. 6, pp. 14–16, 28 and 41.

Gears and Gearing. **Still Going Strong.** Oxy-Acetylene Tips (Oct. 1938), vol. 17, no. 10, p. 231.

Hard-Facing **Problems of Today,** C. C. Pendrell. Iron Age (July 21, 1938), vol. 142, no. 3, pp. 37–39 and 45.

Hard Facing. **Use of Ferrous Phosphate in Applying Hard-Metal Coatings,** M. J. Leahy. Oil Weekly (Aug. 22, 1938), vol. 90, no. 11, pp. 32 and 34.

Hard Facing. **Hardening in Iron and Steel Practice.** Western Machy. & Steel World (Oct. 1938), vol. 29, no. 10, pp. 320–322.

Heat Treatment. **Life of Lathe Bed Ways Lengthened by Flame Hardening.** Iron Age (July 28, 1938), vol. 142, no. 4, pp. 39–45.

Heat Treatment. **Oxyacetylene Heating for Bending, Straightening and Forming,** H. H. Moss. Oxy-Acetylene Tips (Aug. 1938), vol. 17, no. 8, pp. 173–178; see also Heating, Piping & Air Conditioning (Oct. 1938), vol. 10, no. 10, pp. 662–663.

Heat Treatment, Oxyacetylene Process. **Straight as Arrow.** Oxy-Acetylene Tips (Sept. 1938), vol. 17, no. 9, p. 206.

Hydraulic Gates. **Welding Facilitates Fabrication of Flood Gates,** C. H. Jennings. Iron Age (June 16, 1938), vol. 141, no. 24, pp. 36–37 and 93.

Industrial Plants. **How Welding Is Applied to Plant Maintenance and Repairs,** H. R. Wass. Concrete (Aug. 1938), vol. 46, no. 8 (Cement Mill Sec.) pp. 224–226.

Industrial Plants. **Plant Maintenance and Repairs,** H. R. Wass. Machy. Market (Aug. 5, 1938) no. 1970, p. 648 and (Aug. 12) no. 1971, p. 667.

Industrial Plants. **All-Welded Factory Building.** Civ. Eng. (London), vol. 33, no. 379 (Jan. 1938) pp. 28–29.

Iron and Steel Plants. **Special Scrap Cutting Car Employed in Yards of Large Steel Mill,** O. Trentham. Iron Age (Aug. 4, 1938), vol. 142, no. 5, pp. 40–41.

Jigs and Fixtures. **Production Economies Obtained by Use of Welding Jigs and Fixtures,** E. C. Breckelbaum. Welding Engr. (July 1938), vol. 23, no. 7, pp. 15–17.

Natural Gas Pipe Lines. **Half-Soling Gas Pipe Line Cuts Maintenance Cost,** H. Williams. Oil & Gas J. (Oct. 6, 1938), vol. 37, no. 21, pp. 53 and 60.

Oil Wells. **Casing Welding,** P. Reed. Oil & Gas J. (Sept. 29, 1938), vol. 37, no. 20, pp. 66 and 68.

Oil Wells. **Field Welding of Oil Well Casing,** E. W. P. Smith and R. L. Looney. Oil & Gas J. (Sept. 1, 1938), vol. 37, no. 16, pp. 34 and 37–38.

Oxyacetylene Cutting. **Flame Cutting for Modern Structures Has Variety of Applications,** R. W. Sternke. Can. Machy. (July 1938), vol. 49, no. 7, pp. 39–40 and 42.

Oxyacetylene Cutting. **Reconditioning Blast Furnace.** Oxy-Acetylene Tips (Sept. 1938), vol. 17, no. 9, p. 205.

Oxyacetylene Cutting. **Stack Cutting—Newly Developed Flame-Cutting Process,** D. E. Roberts. Machy. (N. Y.), vol. 45, no. 2 (Oct. 1938) pp. 65–71, and (Nov.) no. 3, pp. 198–200.

Oxyacetylene Cutting. **Ingot Splitting.** Oxy-Acetylene Tips (Oct. 1938), vol. 17, no. 10, p. 229.

Oxyacetylene Cutting. **Large Circular Barrel Cairns Accurately Flame-Cut,** W. B. Brower. Iron Age (June 16, 1938), vol. 141, no. 24, pp. 31–33.

Oxyacetylene Welding. **Good Practices in Handling Welding Gases and Equipment,** H. F. Reinhard. Industry & Welding (June 1938), vol. 11, no. 6, pp. 13–14, 16 and 48–49.

Oxyacetylene Welding. **Preventing Welding Fires.** Safety Eng. (Oct. 1938), vol. 76, no. 4, pp. 60–62.

Oxyacetylene Welding. **Make Your Oxyacetylene Welding Success,** C. H. S. Tupholme. Sheet Metal Industries (Oct. 1938), vol. 12, no. 138, pp. 1167–1168 and 1176.

Oxyacetylene Welding. **Welded Joints Have Strength, Ductility and Resiliency,** W. B. Nicholson. Sheet Metal Industries (Sept. 1938), vol. 12, no. 137, pp. 1041–1043 and 1046.

Oxyacetylene Welding of Corrosion-Resistant Steels. Oxy-Acetylene Tips (Sept. 1938), vol. 17, no. 9, pp. 197–204.

Oxy-Gas Cutting. **Fabrication Cost Can Be Cut by Using Portable Machine Cutting.** Welding Engr. (July 1938), vol. 23, no. 7, pp. 21–24.

Penstocks. **Stresses in Welded Pipes with Internal Pressure and End Thrust or Tension,** S. J. Palmer. Engineering (Sept. 2, 1938), vol. 146, no. 3790, pp. 289–291.

Petroleum Pipe Lines. **Maintenance of Pipe Lines,** H. B. Trefz. Oil & Gas J. (Sept. 22, 1938), vol. 37, no. 19, pp. 210 and 219 and (Oct. 6) no. 21, p. 55.

Petroleum Pipe Lines. **Construction of 232-Mile Lance Creek-Denver Line,** J. C. Albright. Oil Weekly (Oct. 3, 1938), vol. 91, no. 4, pp. 17–19.

Petroleum Pipe Lines. **Construction Features of Pipe Line in Rocky Mountain Area,** F. H. Love. Petroleum Engr. (Oct. 1938), vol. 10, no. 1, pp. 43 and 47–48.

Pipe Lines. **Reconditioning Operations of Pipe Lines Are Reviewed,** W. M. Murphy. Oil & Gas J. (Sept. 22, 1938), vol. 37, no. 19, pp. 204 and 209.

Pipe Lines. **Trend in Multiflame Pipe Line Welding,** T. W. Greene. Oil & Gas J. (Sept. 22, 1938), vol. 37, no. 19, p. 220.

Plastics. **Forming Plastics Economically.** Oxy-Acetylene Tips (Aug. 1938), vol. 17, no. 8, pp. 180–181.

Roofs. **Welding Saves 50% in New Type of Roof and Floor Construction.** Elec. News (Oct. 15, 1938), vol. 47, no. 20, p. 40.

Shipyards. **Outstanding Operations at Sun Shipyard.** Machy. (N. Y.), vol. 45, no. 3 (Nov. 1938) pp. 180–183.

Stainless Steel, Architectural. **Decorative Effects with Sheet,** O. B. Bach. Metal Progress (Oct. 1938), vol. 34, no. 4, p. 339.

Stainless Steel. **Stable Stainless Steels for Cold Working and Welding,** V. W. Krivobok. Metal Progress (Aug. 1938), vol. 34, no. 2, pp. 135–139 and 160.

Steam Pipe Lines. **Welding Procedure for Carbon-Molybdenum High-Pressure Power Piping.** Welding Engr. (July 1938), vol. 23, no. 7, pp. 25–28.

Steel Hardening. **Flame Hardening by Oxyacetylene Torch Is Speedy and Flexible.** Can. Machy. (Sept. 1938), vol. 49, no. 9, pp. 52, 54 and 57.

Steel Hardening. **Oxyacetylene Surface Hardening,** A. K. Seemann. Machy. Market (Sept. 9, 1938) no. 1975, pp. 751–752 and (Sept. 16) no. 1976, p. 772.

Steel Hardening. **Selective Hardening with Oxyacetylene Flame,** R. L. Rolf. Am. Soc. Metals—Preprint no. 2 mtg. Oct. 17–21, 1938, 13 pp.

Stresses. **Elastic Models for Studying Stresses in Welded Joints,** E. W. P. Smith. Product Eng. (Oct. 1938), vol. 9, no. 10, pp. 400–401.

Structural Steel. **Shrinkage Stresses in Welding at Large Steel Structures,** W. J. Schneider. Can. Metals & Met. Industries (Sept. 1938), vol. 1, no. 9, pp. 251–252.

Testing. **Acid Etching Weld Test,** O. T. Barnett. Oil & Gas J. (Aug. 18, 1938), vol. 37, no. 14, pp. 62 and 64.

Welded Steel Structures. **Structural Welding Advances under New York City Code.** Eng. News-Rec. (Sept. 15, 1938), vol. 121, no. 11, pp. 325–326.

Welding. **Digest of Welding Processes and Equipment,** K. L. Hansen. Metal Progress (Aug. 1938), vol. 34, no. 2, pp. 115–120.

Welding. **European Welding Practice and American Trends,** C. H. Jennings. Iron & Steel Engr. (Oct. 1938), vol. 15, no. 10, pp. 54–59 (discussion) pp. 60–63.

Welding. **Importance of "Know How" in Metal Fabrication Today,** G. H. Koven. Industry & Welding (Oct. 1938), vol. 11, no. 10, pp. 30, 32–34, and 48.

BOOKS

Practical Handbook of Welding. Gas Welding and Cutting. (Praktisches Handbuch der gesamten Schweisstechnik vol. 1) by P. Schimpke and H. A. Horn. Third enlarged and revised edition; 300 pages; published by J. Springer, Berlin, 1938, price 18 marks. This new edition of the first volume of the well-known Schimpke-Horn Handbook deals with all the theortical and practical aspects of gas welding and cutting equipment and methods. New sections on welding rods, fluxes, and the welding of light metals and thorough revision of the chapters on cutting and the testing and metallography of welds maintain the reputation of the Handbook as a standard text and reference work.

Willem Smit & Co.'s Transformatorenfabriek N. V., Nymegen, Holland have issued a Jubilee volume (Jubileumnummer) in celebration of the twenty-fifth anniversary of the firm. The book consists of 17 technical articles totaling 235 pages written by experts of the firm chiefly on transformer design and welding. The seven welding chapters are:

Joint design and sequence in automatic arc and Unionmelt welding, by W. Gerritsen.

Induction annealing of circumferential pipe welds, by J. J. Roos.

Hardness and ductility in fillet welded structural and ordnance steels, by Dr. P. Schoenmaker.

The technical properties of steel with special reference to welding, by H. A. Bergsma.

The manufacture of welding electrodes from the management standpoint, by L. W. C. Gaymans.

Why is welding preferable to riveting? by A. L. Gerretsen.

Design of large welded transformer boxes (25 ft. long), by A. van Roggen.

Industrial Welding Processes (Procedeele Industriale de Sudură) by Dr. C. Miklosi (Director of the Power Plant and Street Railways of Timisoara, Rumania) and Prof. C. C. Teodorescu (Rector of the Polytechnic College at Timisoara) Vol. 1. Metals and Alloys (226 pp.) Vol. 2. Welding Engineering (377 pp.). Published as Publications Nos. 105 and 106 of the Rumanian Power Institute (Institutuc Român de Energie) Bucharest, 1936. These two volumes form a comprehensive text for college students or others interested in arc, gas, resistance and thermit welding. Vol. 1 is a thorough outline of all phases of physical metallurgy, whereas the second volume is devoted to a detailed description of welding methods and equipment with a brief discussion of welding design. Copies may be obtained from Newnes and Pearson's, Tower House, Southampton Street, Strand, London, W.C.2.

STRUCTURAL STEEL WELDING in New York City*

By ARTHUR N. KUGLER†

STRUCTURAL steel welding is an application of fusion welding the growth of which has been a logical development. Starting with the early applications, under little or no control, which were employed because there was no other way to accomplish the results, structural fabrication by welding has developed steadily until today we have literally thousands of welded steel frame structures. The work of the AMERICAN WELDING SOCIETY, Structural Steel Welding Committee in cooperation with the American Institute of Steel Construction, the International Acetylene Association and other technical associations and individual companies, which work culminated in the "Code for Fusion Welding and Gas Cutting in Building Construction" has been a major factor in tfiis growth and acceptance. The personal efforts in the interests of Structural Welding of the late Professor Frank P. McKibben, past-president of the AMERICAN WELDING SOCIETY contributed materially to the early progress.

Up to July 1933 over 140 cities permitted structural steel welding. From that time on the list grew so rapidly that it was impossible to keep it up to date. Shortly after this the "City Fathers" of New York City gave consideration to the revision of the Building Code and the inclusion of welding in the new one was one of its principal features to which the public press devoted much space. After many hearings at which technical experts testified, the new code, permitting the use of welding in structural fabrication and erection was adopted in July 1937 and became effective January 1, 1938. New York City was not the first to adopt welding but being the largest city in the United States its decision influenced many smaller cities and the number of municipalities permitting welding has grown remarkably this year. Federal and State engineering offices have taken renewed interest in the subject. In short, structural steel welding is coming into its own. Our own fellow member, Mr. Gilbert D. Fish, Chairman of the AMERICAN WELDING SOCIETY, Structural Steel Welding Committee is responsible for many of the welded structures erected to date. It is he who has designed the welded connections on the "all welded" buildings built in New York City.

Since the first of the year five all welded steel frame buildings have been erected in New York City with a steel tonnage of over 2400 tons. In addition, five buildings at the World's Fair and one church have been shop welded and field bolted. The first of these buildings, Kensington House located at 20th Street and Seventh Avenue was started March 30, 1938 and was ready for occupancy about September 1st. It is a fourteen story apartment building involving over 720 tons of steel both shop and field welded. Figure 1 shows the steel frame of this building completely erected.

The connecting materials amounted to 63,507 pounds or 31¾ tons. The welding involved a total of about 11,870 feet of all sizes and includes both shop and field welding. The amounts of shop and field welding by the various sizes are given below.

SHOP WELDING	
¼-inch fillet welds	3590 feet
5/16-inch fillet welds	3309 feet
⅜-inch fillet welds	1274 feet
TOTAL—Shop Welding	8173 feet
FIELD WELDING	
¼-inch fillet welds	2066 feet
5/16-inch fillet welds	1266 feet
⅜-inch fillet welds	339 feet
½-inch fillet weld	26 feet
TOTAL—Field Welding	3697 feet
TOTAL ALL WELDING	11,870 feet

Shop welding	8173 feet	69%
Field welding	3697 feet	31%
Total welding	11,870 feet	100%

In rapid succession three public school buildings were completely welded each of which involved more than 400 tons of steel. Two of these schools were in the Boro of Queens and one in the Boro of Bronx. These school buildings, covering a large ground area, are three stories high with a roof playground. During September a seven-story addition to a New York Telephone Company exchange was started. This building involves about 450

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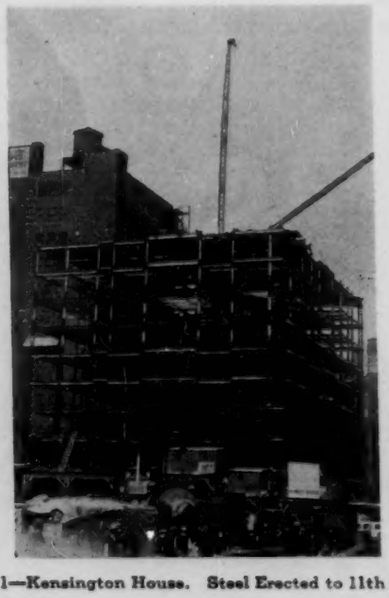


Fig. 1—Kensington House. Steel Erected to 11th Floor

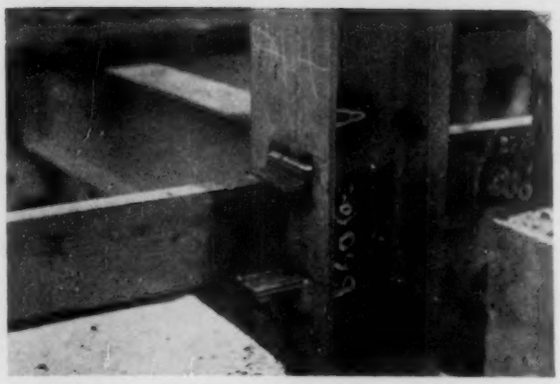


Fig. 2—Angle Seat Connection with Clip Angle at Top

tons of steel. The six shop welded, field bolted structures represent a total of about 1700 tons. Thus, in the short space of nine months 4135 tons of structural steel have been welded in New York City—and it should be remembered that construction work in general is at a low level.

The new building code of the city of New York permits the use of welding along with the older standard methods of construction, riveting and bolting. The code stipulates that the design shall be made by an engineer versed in the art of structural steel welding design. It further requires that each welding operator pass qualification tests to demonstrate his ability to weld in the various positions. These qualification tests follow closely those given in the AMERICAN WELDING SOCIETY CODE. Each operator pays for his own test and is qualified for a period of one year, after which time he must take a simple retest. Each operator is required to make two specimens in the flat, vertical and overhead positions, depending on whether or not he will weld in these positions in the field. These test specimens consist of two bars, $^3/_4$ inch thick by 3 inches wide by approximately 9 inches long, spaced $^1/_2$ inch apart across the 3 inch width and then joined above and below by two splice plates 3 inches wide by $^3/_8$ inch thick by $4^1/_2$ inches long. Fillet welds are made across the 3-inch end of these splice plates on each side.

The Board of Standards and Appeals issues the rules governing these qualifications tests and the following results are required of the test specimens:

For filler metals, Grades 2, 4, 10 or 15, it is required that the ultimate tensile strength shall be not less than 80 kips (kip = 1000 lb.); for filler metal of Grades 20, 30 or 40, a minimum of 67 kips is required. However, in view of a requirement for filler metals of Grade 10 or better to be used on structural steel welding, it means that only shielded arc electrodes can be used on the qualification test and, therefore, all test pieces must develop the value of 80 kips. The Department of Housing & Building has a Board of Examiners for Welders appointed from its own staff and these men conduct the welding examination and witness the testing of the specimens and provide the certifications for the welders. Each operator must be an American citizen and show evidence of several years previous welding experience in either structural steel, pressure vessel or machinery fabrication welding.

The Code further requires that the welding be subjected to competent supervision and inspection. In general for this purpose, consulting engineers have been retained to insure that the welding is placed where it should be and the proper dimensions of welds are maintained. One further requirement is placed upon structural steel welding in the city of New York and that is that only approved electrodes be employed in the welding of structures. The responsibility for testing and approving electrodes is lodged with the Board of Standards and Appeals, which board through its rules requires that all electrodes conform to the American Society for Testing Materials' Specification A205-37T. These specifications are the filler metal specifications of the AMERICAN WELDING SOCIETY which have been revised and brought up to date by a joint committee of the two societies. The Board of Standards and Appeals is requiring each manufacturer to submit his rods to the test prescribed in the specification in the presence of a member of their department. Rods which satisfy the requirements of Grade 10 or better are acceptable for structural steel welding in New York City, which means that only shielded arc electrodes are permissible. Grade 10 requires that the 0.505 inch all-weld-metal tensile test specimen develop 60,000 psi and 20% elonga-

Fig. 3—Illustrating Several Seat Angle Connections. Operator Welding Column Connection

Fig. 4—Seat Connection Fabricated of Half an I Beam

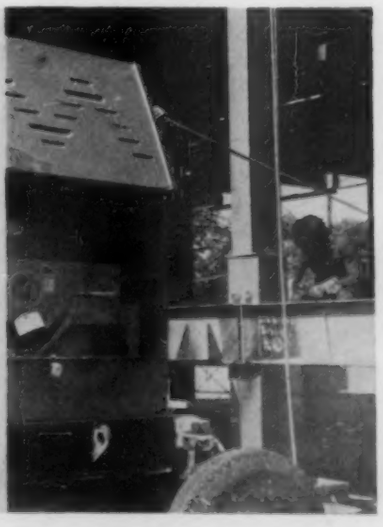


Fig. 5—Half I Beam Connections Used on Outside Channel

tion in 2 inches in the non-stress relieved condition.

On the first all-welded building constructed in New York City, it was indeed fortunate that the contractor erecting and welding these frames, had had previous experience in structural steel welding. It was, therefore, possible to proceed with the utmost safety and speed and secure reliable data and information on this new procedure. The first building to be erected was the 14-story apartment house and being of such a large size, wind-bracing was a necessary consideration. Therefore, seat connections were used almost exclusively on this building. Seat connections were of the two general types, namely, a simple angle seat for the smaller end reactions and for the heavier reactions, a "T" connection made from half an I beam. At the top flange of these seat connections was welded a clip angle for stiffness. Typical seat connections are shown in Figs. 2, 3, 4 and 5.

The seat angles and the "T" section seats were welded to the columns in the shop.

The next three buildings to be erected were public school structures, only three stories high, equipped with the roof playgrounds. On these web connections were used almost exclusively. See Figs. 6 and 7. However, on these buildings they did provide for future additions by welding on seat connections in the form of half an I beam. Column connections were made by means of a bearing plate between the various column sections as shown in Figs. 8 and 9. These plates were shop-welded to the top of the column section and the adjoining upper column was provided with small clip angles for erection bolting. When the column was bolted in place and made true, then the welder merely deposited sufficient fillet welding around the flanges to maintain the column in position. First floor columns were provided with angles welded to the web or flanges in the shop. Holes were drilled in the outstanding leg to receive the foundation bolts. See Fig. 10.

On the seven-story telephone building, a somewhat different method of providing lateral stiffness was employed. Here, instead of the clip angle used earlier, a plate was employed welded to the top flange of the beam and welded continuously around the edge adjoining the column. This, of course, provides a more rigid connection than that provided for by the clip angle. The welding crew required for this work varies with the size of job. The 14-story apartment building is perhaps the best example to quote from point of view of labor set-up. There were six union steel worker welders employed on this work at a rate of $\$1.92^1/_2$ per hour. One helper was provided, whose function was to keep the

Fig. 6—Welding Operator Making Web Connection

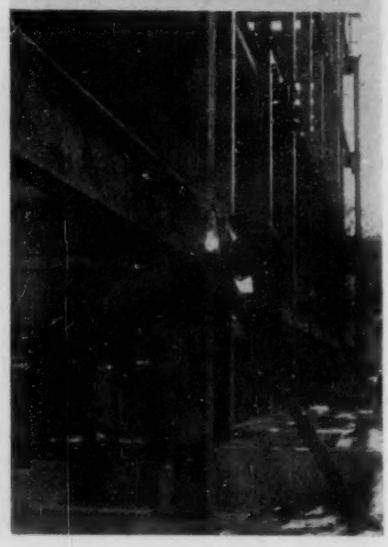


Fig. 7—Welding a Web Connection

Fig. 8—Close-Up of Welding a Column Connection

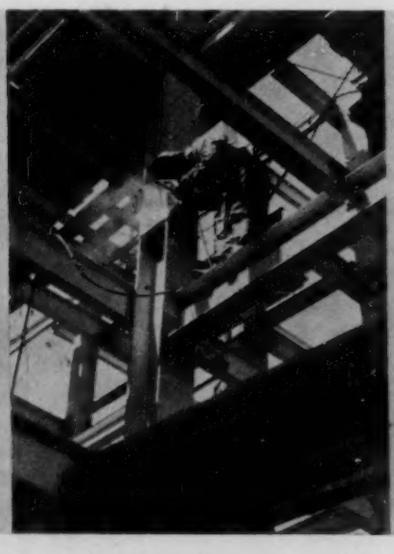


Fig. 9—Making a Column Connection. Note Also Seat Angle Connections

Fig. 10—Illustrating Method of Connecting Columns to Foundation

welders supplied with electrodes and also act as waterboy. The helper received $1.25 per hour. In addition, a stationary engineer was required to look after the gas engines and see that they were properly oiled and had sufficient gasoline. This man's rate was $1.75 per hour. This constituted the electric welding crew for this job, involving 720 tons of steel. Obviously, there were other collateral labor and supervision necessary. However, this gives some idea of the direct labor necessary in welding.

A careful study was made of production on this job for the purpose of providing some fundamental data for cost estimating. The average daily production of these six welders was 7 1/2 linear feet of equivalent quarter-inch per man hour. The term "equivalent quarter inch fillet welds" is used inasmuch as several different sizes of welds were encountered such as 1/4 inch, 5/16 inch, 3/8 inch and 1/2 inch welds. To provide a common denominator for estimating purposes, these were expressed in terms of the equivalent amount of 1/4-inch fillet welds. The following cost analysis gives the actual welding cost per foot of weld completed but does not include overhead, supervision, insurance, profit and incidentals.

Structural Steel Welding Cost Analysis

Welding with Gasoline Engine Driven Machines

LABOR (per hour)		
1—Welding operator	$1.925	
1/6—Stationary engineer (1/6 of $1.75)	.292	
1/6—Helper (1/6 of $1.20)	.20	
Sub-total—Labor		$2.417
MATERIAL (per hour)		
Gasoline (assume 2.0 gals. per hour at 13.5¢ per gal.)	$0.27	
Oil (arbitrarily assumed at 3¢ per hour)	.03	
Electrodes (at 7.5 ft. per hour about 1 3/4 lbs. consumed at 10¢ per lb.)	.175	
Sub-total—Material		$0.475
TOTAL—LABOR & MATERIAL (per hour)		$2.892
PRODUCTION (per hour)		7.5 ft.
COST PER FOOT OF EQUIVALENT 1/4-INCH FILLET WELD		
$\frac{\$2.892}{7.5} = \$0.386$		$0.386

Six 300-ampere gasoline engine powered welding machines were employed. The gasoline consumption will be between 1.5 and 2.0 gallons per hour depending on the work factor.

From this analysis it will be seen that material constitutes but 16 1/2% of the total cost, while labor amounts to 83 1/2%. On large jobs using a number of gasoline engine machines the wisdom of employing a stationary engineer to operate them is apparent. On smaller jobs with fewer machines doubtless it would be more economical to dispense with the engine operator if labor conditions permitted. On the first four jobs no less than four machines were used and the stationary engineer was employed.

The owner of the first all-welded building, the 14-story apartment house has reported a net saving to him of $5000 made possible by welding. Further, in the erection of the elevators it was reported by the installation men that due to greater rigidity and improved alignment of the structure it was possible for them to install the rails more rapidly, with less shimming and consequently better alignment.

Thus, has structural steel welding been introduced in the City of New York. That its use will grow is admitted by all who have observed these first few jobs. Its inherent advantages such as noise elimination, reduction in weight with equal capacity for load, greater freedom for the designer and fabricator, ease and simplicity with which alterations and additions may be made and many others insure the continued growth of this construction procedure.

The general public and the press are primarily interested in the elimination of the noise of riveting. That this is a very important factor was brought out when the news reels took pictures of Kensington House. To illustrate this advantage sound movies were taken on a riveted structure and compared with those on the welded building.

An additional advantage for structural steel welding design has recently been advanced. On structures such as highway bridges which are not encased in masonry we are inclined to look on the steel frame as lacking artistic lines. This is particularly so when rivets are used. It is, therefore, somewhat of a novelty to record here that a welded highway bridge design is being prepared in order to obtain a structure of pleasing lines.

RESISTANCE WELDER MANUFACTURERS' Specifications

Seam Welder Specifications

1. There will be three sizes of standard machines:
   Light: 50 and 75 kva.
   Medium: 100, 150, 200 kva.
   Heavy: 250, 300, 400 kva.
2. Standard drive arrangements as follows, each applicable to all ratings:
   A. Circular upper or lower gear
   B. Circular upper or lower knurl
   C. Circular double knurl
   D. Longitudinal upper or lower gear
   E. Longitudinal upper or lower knurl
   F. Longitudinal double knurl
   G. Universal upper gear
   H. Universal upper knurl
3. Standard throat depths shall be as follows (-in.):

Light	18	24	30	36		
Medium	18	24	30	36	42	48
Heavy		24	30	36	42	48

4. All machines will be equipped with combination foot valve and limit switch and connected in series with pressure switch in air cylinder. Solenoid valves not standard equipment.
5. All air operated machines are to be complete with air line lubricator, regulator and air gage.
6. All machines will be completely provided with external water cooling tubes and water pan.
7. All machines will be provided with one each upper and lower roll, as tabulated in par. 9, except that when extra arms are furnished one roll will be furnished with each extra arm.
8. Drive will be by means of constant speed sleeve bearing motor, through vari-speed pulley.

9.		Light	Medium	Heavy
1.	Stroke—min. and max.	2–3	2–3	2–3
2.	Max. roll diam.	7	8	10
3.	Max. roll thickness	3/4	1	1 1/4
4.	Max. pressure @ 80 lb. air	1005	2280	3078
5.	Projected bearing area (±10%)			
6.	Motor Hp. (constant speed)	3/4	1	1 1/2

NOTES:

1. Working stroke for both new and worn out welding wheels.
4. In addition to weight of head, cylinders to produce pressures less than that shown are optional.
5. Projected bearing area is journal diameter times length in sq. in.

Spot Welder Specifications

	Rated Kva.	Type	Taps	Base Horn Length In.	Max. Listed Horn Length In.	Horn Size In.	Point Holder In.
	10	Manual	4	6	18	2	1
Small							
	15	Manual	4	6	24	2	1
	20	Manual	6	8	30	2 1/4	1
	20	Air	6	8	30	2 1/4	1
	20	Motor	6	8	30	2 1/4	1
Medium							
	30	Manual	6	8	36	2 1/4	1
	30	Air	6	8	36	2 1/4	1
	30	Motor	6	8	36	2 1/4	1
	40	Manual	8	12	42	2 1/2	1 1/4
	40	Air	8	12	42	2 1/2	1 1/4
	40	Motor	8	12	42	2 1/2	1 1/4
Large							
	50	Manual	8	12	42	2 1/2	1 1/4
	50	Air	8	12	42	2 1/2	1 1/4
	50	Motor	8	12	42	2 1/2	1 1/4

Standard machines include the following equipment:

(*A*) Water-cooled points and point holders of any standard type and in sizes listed above.

(*B*) Contactors are included with all machines of the following ratings:

Kva.	220 V.	Kva.	220 V.	Kva.	220 V.
10	50 amps.	20	100 amps.	40	100 amps.
15	50 amps.	30	100 amps.	50	150 amps.

Contactors may be mechanically operated or of the standard magnetic type.

Welding Pressures: The following maximum pressures are standard, on base throat depth, with decreasing pressure as throat depth is increased. In all cases pressure is measured at the welding tips.

Small—500 lb. @ 6 inch throat: Medium—1000 lb. @ 8 inch throat: Large—1000 lb. @ 12 inch throat.

Above pressures apply to both manually and motor operated machines. Air operated machines may be provided with cylinders of such size that the above pressures will not be exceeded by more than 50%.

Manually operated machines are provided with pass-through switches which may operate directly in the primary circuit or be used to actuate magnetic contactors.

Timers, where and if used, are not included.

Air operated machines include either foot valve and limit switch or solenoid valve and foot switch.

Air line lubricator, pressure gage, pressure regulator and pressure switch (if used) are standard.

Motor driven machines include motor, motor starter and variable speed pulley.

Lower horn is provided with a vertical adjustment not to exceed 12 inches.

Light Duty Press Welder Specifications

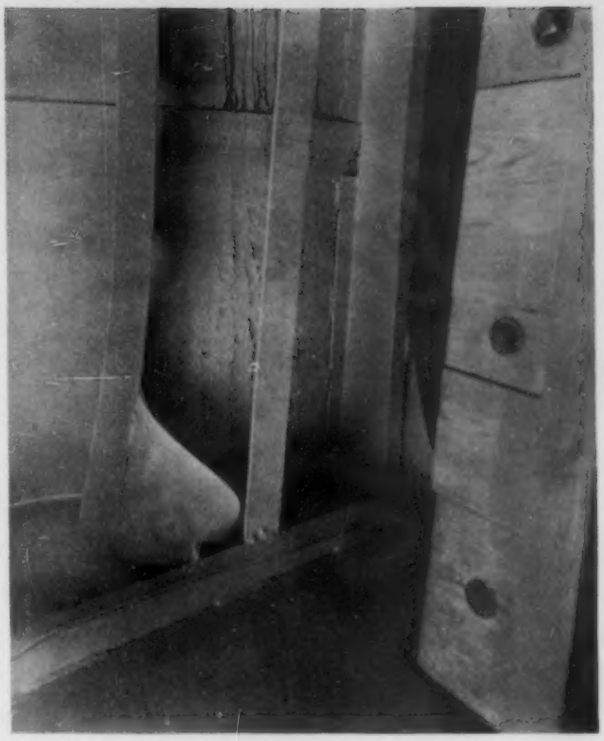
Kva.	Throat	Type	Max. Pressure	Specifications
30	12	Air	1575	Light duty press welders are of the lower HORN type. Horns may be mounted on face plates with a maximum vertical adjustment of 12 inches; or may be of the column type with swinging adjustment in addition to vertical adjustment. Upper and lower horns to be 2 1/2 inches and 2 3/4 inches diameter, respectively, with any standard 1 1/4 in. water cooled points and holders.
30	18	Air	1275	
30	24	Air	1275	
30	30	Air	1000	
30	12	Mech.	1000	
30	18	Mech.	1000	
30	24	Mech.	1000	
30	30	Mech.	1000	
40	12	Air	1575	
40	18	Air	1275	
40	24	Air	1275	
40	30	Air	1000	Machines of 24-inch throat depth and over include adjustable lower horn brace.
40	12	Mech.	1000	
40	18	Mech.	1000	
40	24	Mech.	1000	All press welders are provided with all equipment necessary for complete and proper operation with the exception of (1) welding contactor, (2) timer (if required or used), (3) special control apparatus. We recommend the use of two pole contactors.
40	30	Mech.	1000	
50	12	Air	1575	
50	18	Air	1275	
50	24	Air	1275	
50	30	Air	1000	
50	12	Mech.	1000	
50	18	Mech.	1000	Air operated machines are equipped with air pressure gage, pressure regulator, air line lubricator, and are provided with (1) solenoid valve, foot switch and pressure switch, or (2) foot valve, limit switch and pressure switch. Air reservoirs are not included.
50	24	Mech.	1000	
50	30	Mech.	1000	
75	12	Air	1575	
75	18	Air	1275	
75	24	Air	1275	
75	30	Air	1000	
75	12	Mech.	1000	Motor operated machines are complete with (1) constant speed motor, (2) motor starter, (3) variable speed drive.
75	18	Mech.	1000	
75	24	Mech.	1000	
75	30	Mech.	1000	
Regulators—heat or current control have a maximum of 16 steps.				Mechanically operated machines, whether of the direct cam or cam and toggle type have springs as the source of pressure.

Medium Duty Press Welder Specifications

Kva.	Throat	Type	Max. Pressure	Specifications
75	12	Air	4000	All press welders are provided with all equipment necessary for complete and proper operation with the exception of (1) welding contactor, (2) timer (if required or used), (3) special control apparatus. We recommend the use of two pole contactors.
75	18	Air	3000	
75	24	Air	2000	
75	30	Air	2200	
75	12	Mech.	2500	
75	18	Mech.	2500	
75	24	Mech.	2500	
75	30	Mech.	2500	
100	12	Air	4000	Air operated machines are equipped with air pressure gage, pressure regulator, air line lubricator, and are provided with (1) solenoid valve, foot switch and pressure switch, or (2) foot valve, limit switch and pressure switch. Air reservoirs are not included.
100	18	Air	3000	
100	24	Air	3000	
100	30	Air	2200	
100	12	Mech.	2500	
100	18	Mech.	2500	
100	24	Mech.	2500	
100	30	Mech.	2500	Press welders provided with knees have terminals suitable for mounting dies, but dies, die holders and horns are not standard. Motor operated machines are complete with (*a*) constant speed motor, (*b*) motor starter, (*c*) variable speed drive.
125	12	Air	4000	
125	18	Air	3000	
125	24	Air	3000	
125	30	Air	2200	
125	12	Mech.	2500	
125	18	Mech.	2500	
125	24	Mech.	2500	
125	30	Mech.	2500	Mechanically operated machines, whether of the direct cam or cam and toggle type have springs as the source of pressure.
				Regulators—heat or current control has a maximum of 16 steps.

Heavy Duty Press Welder Specifications

Kva.	Throat	Type	Max. Pressure	Specifications
150	12	Air	6300	All press welders are provided with all equipment necessary for complete and proper operation with the exception of (1) welding contactor, (2) timer (if required or used), (3) special control apparatus.
150	18	Air	6300	
150	24	Air	5100	
150	30	Air	5100	
150	12	Mech.	5000	
150	18	Mech.	5000	
150	24	Mech.	5000	
150	30	Mech.	5000	Air operated machines are equipped with air pressure gage, pressure regulator, air line lubricator, and are provided with (1) solenoid valve, foot switch and pressure switch, or (2) foot valve, limit switch and pressure switch. Air reservoirs are not included.
200	12	Air	6300	
200	18	Air	6300	
200	24	Air	5100	
200	30	Air	5100	
200	12	Mech.	5000	
200	18	Mech.	5000	
200	24	Mech.	5000	Press welders provided with knees have terminals suitable for mounting dies, but dies, die holders and horns are not standard. Motor operated machines are complete with (1) constant speed motor (2) motor starter, (3) variable speed drive.
200	30	Mech.	5000	
250	12	Air	9100	
250	18	Air	6300	
250	24	Air	6300	
250	30	Air	5100	
250	12	Mech.	5000	
250	18	Mech.	5000	Mechanically operated machines, whether of the direct cam or cam and toggle type have springs as the source of pressure.
250	24	Mech.	5000	
250	30	Mech.	5000	
				Regulators—heat or current control have a maximum of 16 steps.



Interior Framing and Plates of All-Welded Barge Following Hurricane Collision with Freighter FAIRFIELD. In Spite of Deep Dent Made in Hull, Major Welds Held and No Water Was Taken

Welded Barge Withstands Hurricane Collision

The 80 mile tropical hurricane that recently scattered death and destruction along the North Atlantic Seaboard created in its fury, a number of marine accidents unprecedented in those waters. Many ships of all sizes were thrown up on land, piled on wrecked wharves and several were lost through sinking.

Wind and water raged even in sheltered New York Harbor. On the afternoon of September 21st, the freighter Fairfield (2848 gross tons) tied up at 55th Street Pier, Bush Terminal, parted its mooring lines and charged with devastating force across the slip. A ship of this size on the loose is a major problem in anybody's water. The Fairfield, with no crew on board, riding high and light, was an unusual menace.

All-Welded Barge Following Three Hour Buffeting by Freighter FAIRFIELD During New York Hurricane. In Spite of Dents Barge Took No Water and Lost No Cargo

Tied against the slip bulkhead, directly in the path of the helpless Fairfield, was the Cleary Bros. coal barge Andrew J. Gonnoud, which had been unloading at the Kings County Light & Power Company's pier when the storm caused operations to stop at 2:00 P.M. Driven by the wind velocity and the surging water, the Fairfield struck the Gonnoud full force on the starboard side aft, with her sharp bow end.

The Gonnoud is a steel barge, of all-welded construction, one of several recently built by Dravo Corporation and placed in New York Harbor service. She withstood the first impact, but the Fairfield, drawn back with the water, soon came riding in for a second collision.

Harbor operators, hearing of the situation, watched the battle with eager interest. If the Gonnoud sank, the coke unloading dock of the Kings County Light & Power Company would have been bottled up. Through the long afternoon the Fairfield pounded recoiled and pounded again. At least thirty-eight times she struck the Gonnoud, wedging the barge between the slip bulkhead and her cleaving steel prow. At one point, the steel side of the Gonnoud was hammered inward about 10 inches.

When the Fairfield finally was brought under control at 5:00 P.M. the Gonnoud was dented and battered on both sides, but she had not opened or shipped any water whatever. One blow had landed squarely on a vertical weld which held in spite of the terrific force and weight. Operators agreed that a wooden barge would have been ripped open and sunk, her load spilled on the harbor bottom. The Gonnoud was able to finish unloading and was then taken to a repair dock for survey.

WELDING BRONZE AND OTHER Non-Ferrous Alloy Piping*

By H. D. LANTERMAN†

THE welding of bronze and many other non-ferrous alloys is today an accepted fact in all industry. Articles in trade journals and welding magazines constantly call attention to instances where non-ferrous equipment has been fabricated or repaired by welding. Bronze-welding is daily saving literally thousands of dollars through the prevention of costly replacements and even more costly plant shutdowns. The use of welding has been responsible for a great reduction in spare-part inventories.

Initial developments in the welding of these non-ferrous alloys were confined largely to the attainment of a weld metal which would satisfy strength and ductility requirements. In those days the welding supervisor's job was a comparatively easy one. Today, however, he is called upon to produce welds in non-ferrous alloys which will be similar to these alloys or superior to them in many other characteristics. One of the most important problems facing him is the development of welds to resist corrosion.

A pamphlet published in October 1936, by *Chemical and Metallurgical Engineering* lists seventy-six copper and copper base alloys and indicates that in accordance with the manufacturers' recommendations at least forty-three of these can satisfactorily be fabricated by welding. This list does not include the alloys of nickel, lead, silver, tantalum and the noble metals. Many additional alloys have undoubtedly been developed since this pamphlet was published.

* Presented at 19th Annual Meeting, AMERICAN WELDING SOCIETY, Detroit, Oct. 16 to 21, 1938.

† Carbide and Carbon Chemicals Corporation, South Charleston, West Virginia.

Fig. 1—Specially Constructed Welding Tables in the Foreground of This Model Welding Shop Are Used for the Fabrication of Copper, Aluminum and Other Non-Ferrous Alloy Piping

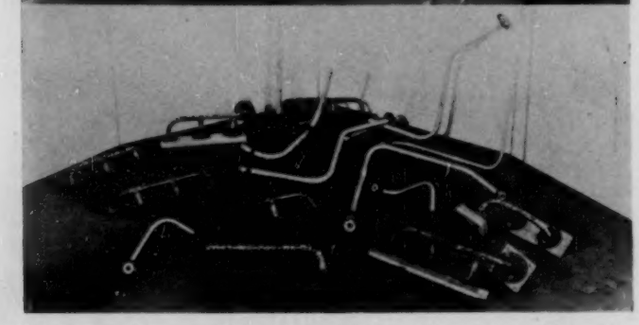


Fig. 2—Several Pieces of Non-Ferrous Piping on Which Fabrication Has Been Completed

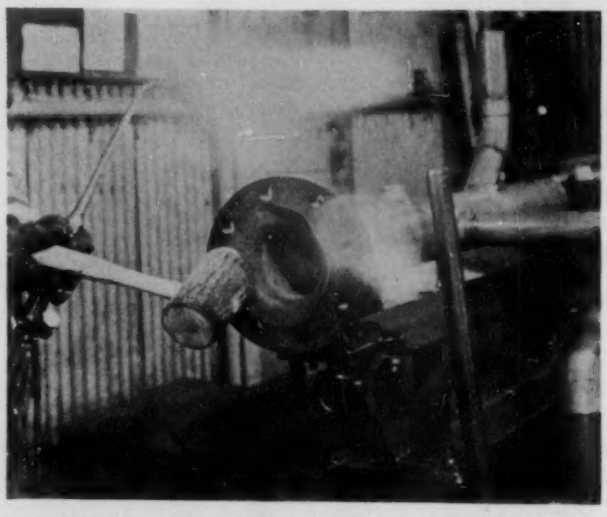


Fig. 3—A Van Stone Flange Is Made in This 4-Inch Copper Pipe by Oxy-acetylene Heating the End and Then Beating the Edges Back Against the Steel Back-Up Flange

The welding supervisor either in a modern fabricating shop or in the maintenance department of any large industrial plant may from time to time be called upon to weld any or all of these modern alloys. The welds made by the men under his supervision must satisfy not only tensile, compressive, ductility, impact and similar physical tests, but may also be required to stand up under extremely severe corrosion experience. Many of these new non-ferrous alloys have been developed to meet the growing demand of the chemical industry for materials to withstand the corrosive effect of modern chemicals. When it is considered that the welding supervisor in the construction or maintenance departments of this industry must develop procedure controls for welded products that will resist the corrosive effect of modern chemicals as well as or better than do the alloys themselves, it is apparent that his job requires unusual qualifications.

The job is, however, by no means impossible. It does not necessarily require a metallurgical engineer. It does require a man who has a working knowledge of what happens to metals and alloys when subjected to the intense heat of the welding blowpipe. The manufacturers of these alloys and the service engineers of the manufacturers of welding equipment and supplies stand ready and anxious to lend every aid to the welding supervisor. The various trade journals and welding magazines contain a wealth of valuable information. The fundamental principles of welding combined with past experience form a background on which to build procedure controls for each new welding problem encountered. Standard procedure controls are available for many

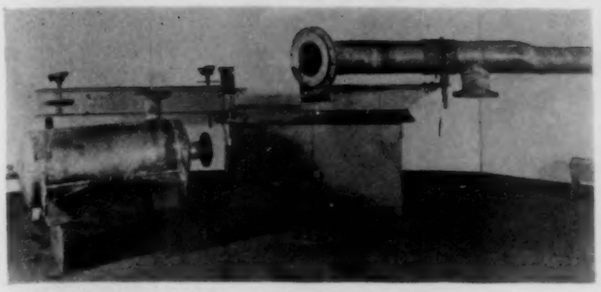
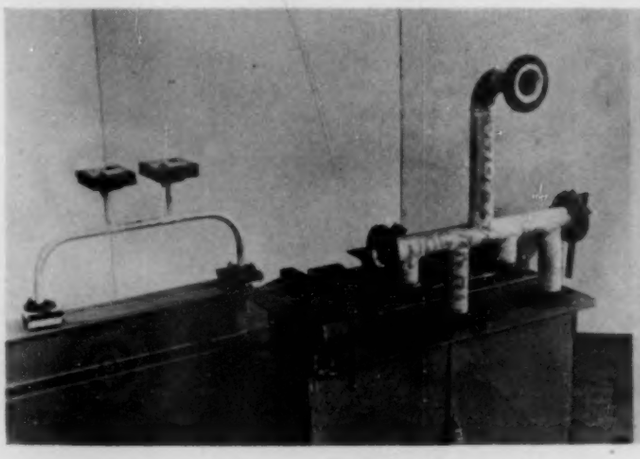


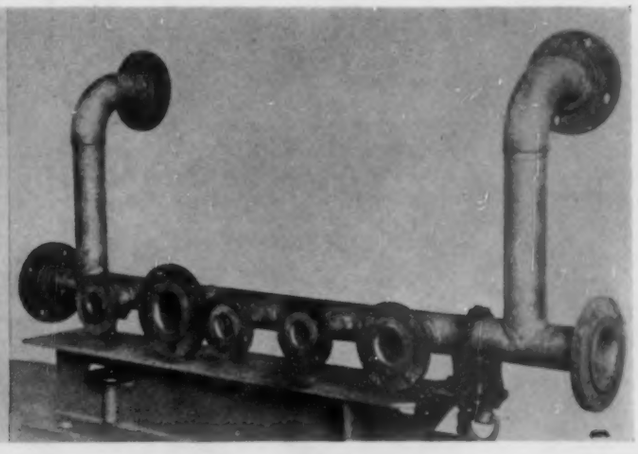
Fig. 4—Close-Up View of Several Pieces of Non-Ferrous Piping on Which Fabrication Has Been Completed

applications. These have been tested by time and found to be satisfactory. Of necessity, however, these published procedure controls are frequently so broad that they cover general requirements only. In the final analysis each welding supervisor must develop his own procedure control to exacting details required for each particular alloy and corrosion problem. Too much stress cannot be laid upon the fact that a very slight deviation in the parent metal, the weld metal, or the corrosion requirements to be met may spell the difference between success or failure. Wherever possible and wherever time permits, sample welds should be made and subjected to actual experience tests. Where actual experience tests are not possible because of time limitations, accelerated tests will often indicate whether the weld may be expected to be satisfactory or not.

In a recent installation of welded piping fabricated under the writer's supervision, stainless steel pipe was required to be welded to withstand the action of acetic acid. Several sample welds were made by different operators and the welds were subjected to immersion in boiling acetic acid for a specified period of time. The results indicated that both the pipe and the weld metal would be satisfactory for a service of approximately twenty years. Fortunately it was discovered before these tests had proceeded too far that not only would the welds be subjected to boiling acetic acid but that an unusually large quantity of oxygen would be present due to aeration. The welds were retested in boiling aerated acetic acid and it was found that due to the aeration, the probable length of life had been reduced from twenty years to two years. Further changes in the procedure control—the introduction of stabilizing elements in both the stainless steel and the stainless steel welding rod—resulted in an improved weld with an expected length of satisfactory service of at least four years. The piping for this unit has been in continuous service for five years and all welds are still satisfactory. Failure to have recognized that this piping would be subjected to the aeration phase of the process would undoubtedly have resulted in a procedure control which would have produced welds far below the standard ultimately reached. This experience emphasizes the importance of making a careful study of all factors entering into each welding problem.

The above steps are aimed to secure a weld metal which is as nearly perfect as is possible for the service to which it is to be subjected. When the welding supervisor has developed such a procedure control, however, his job is only well started. Costs count whether in new construction or in maintenance welding, and this phase must receive thorough consideration. One of the first questions the welding supervisor must ask himself is how much he can economically spend to "tool up" for any particular job. This may include the welding shop itself, cost of welding supplies, the method of conveying the materials in and out of the shop, the type of welding tables and apparatus used and many other items.





Figs. 5 and 6—Close-Up Views of Several Pieces of Non-Ferrous Piping on Which Fabrication Has Been Completed

1938 BOUND VOLUME

Bound Volumes of the JOURNAL of the Society for the year 1938 will be available shortly with imitation black leather covers. Contains a wealth of information on the latest developments in welding. Also contains Subject and Authors' Index. Price, $5.00 plus postage to members; $6.50 to non-members.

Welding Society ACTIVITIES — Related Events

INTERNATIONAL ACETYLENE ASSOCIATION TO MEET IN HOUSTON

The 39th Convention of the International Acetylene Association is to be held in Houston, Texas on March 8, 9 and 10, 1939. Headquarters will be at the Rice Hotel.

In announcing the unanimous decision of the Officers and Directors, the Secretary of the Association referred to the splendid convention of the Association in Birmingham last year—the first in the South—also to the increasingly numerous requests and invitations that have been received by the Association during recent years to visit the great Southwest.

An interesting technical program, covering the most important developments in the application of the oxyacetylene process of welding and cutting is in preparation. Announcements of subjects and speakers are to be made at an early date.

METALS AND ALLOYS

The regular subscription to Metals and Alloys has been reduced from $3.00 per year to $2.00 per year with a two-year price of $3.00.

The AMERICAN WELDING SOCIETY has made arrangements to supply its members with subscriptions at $1.00 per year providing five or more members order subscriptions at the same time. Those who wish to take advantage of this offer by forming a group of five or more should send their money and orders to Mr. John Zellner, Circulation Manager, Metals and Alloys, c/o Reinhold Publishing Corp., 330 West 42nd Street, New York, N. Y.

WELDING SCHOOL OF PITTSBURGH

The Welding School of Pittsburgh was organized for the purpose of providing a place where ambitious young men would learn the fundamentals of good welding practice and to develop the operating ability which would qualify them to weld on the widest variety of work possible. The school is devoted entirely to teaching of welding.

All courses cover a minimum of a hundred hours. One of the outstanding features of the school is that if they find a student is not welding-minded at the end of twenty-five hours, they tell him so and charge him only for the twenty-five hours and not for the full course.

WELDING CLINIC

The Sixth Annual Welding Clinic was held by the Weldrite Company and Prest-O-Lite Service, Inc., Long Island City on October 27th. From 2 P.M. to midnight there were interesting exhibits, demonstrations and talks. These exhibits included use of liquid gases, fluxes in gas line, pipe welding, production welding, heavy cutting demonstrations, maintenance welding, underwater cutting and the welding of ferrous stainless steels and non-ferrous metals. Over a thousand people attended.

WELDING CATALOG

Air Reduction Sales Co., 60 East 42 Street, New York City, has announced the publication of two new catalogs (price lists separate), covering it's entire line of Airco welding and cutting apparatus and supplies.

Catalog 22, which contains 32 profusely illustrated pages, depicts hand welding and cutting torches and tips, pressure regulators, fluxes, rods and other supplies.

Catalog 21 is designed to assist the large user of oxyacetylene equipment and electric arc welding machines. It contains 64 pages which show, in addition to those items in Catalog 22, additional information dealing with acetylene generators, industrial gases and oxyacetylene machines.

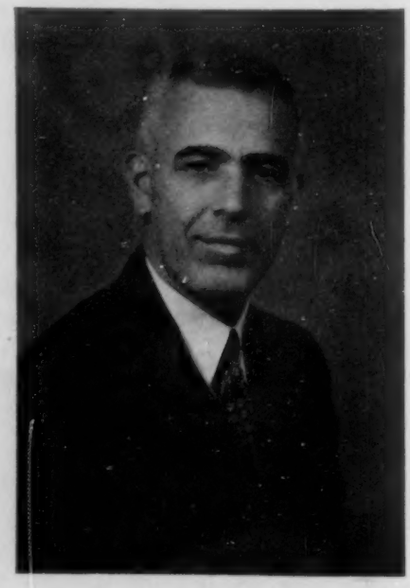
LECTURE COURSE

The Institute of Technology of the University of Minnesota in cooperation with the Northwest Chapter of the AMERICAN WELDING SOCIETY plans to conduct an advanced course in welding problems at its Continuation Study Center which will involve design, metallurgy and metallography, testing and inspection stress analysis, economics, etc. The dates set for this course are February 9, 10, 11, 12, 1939. It is intended that this course should meet the needs of engineers who desire knowledge in the latest developments in welding. Since only the theoretical aspects of welding will be discussed, this course will not appeal to the average welding operator. Nationally known authorities as well as members of the faculty will discuss the various problems with different interest groups, the members of which shall be furnished preprints of the addresses prior to the meetings. Rooms and meals are available at the Center to accommodate those who desire to stay on the campus throughout the course at a rate of $2.50 per day. The fee for the course including preprints will not be over $10.00. Registration must be made not later than January 15, 1939.

Further information relative to this course may be obtained from Professor Charles A. Koepke or Professor Thomas P. Hughes of the Mechanical Engineering Department, University of Minnesota, Institute of Technology, Minneapolis.

WILDER A. CHAPMAN

Mr. Wilder A. Chapman has been appointed Manager of Laboratories for Robert W. Hunt Company, Engineers, with headquarters in Chicago.



Turner C. Smith

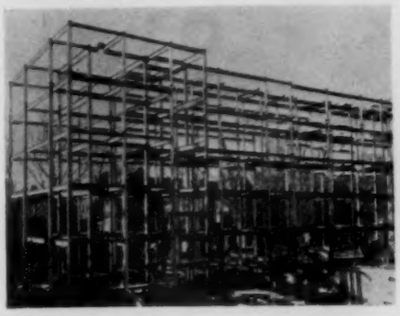
OUR SECOND VICE-PRESIDENT

Turner C. Smith of General Petroleum Corporation, Los Angeles, Calif. is Structural Engineer in the general engineering staff of the General Petroleum Corporation, and is chairman of its engineering committee on oil storage tanks. He is also a member of its committees on unfired pressure vessels and valves for oil field, pipe line and refinery services.

He has been an active member of the AMERICAN WELDING SOCIETY for more than a decade, and has served as chairman of the Los Angeles Section, and as vice-president of the Pacific Coast Division. He is also a member of the A. S. A., the Pacific Coast Building Officials' Conference and the Structural Engineers' Association of Southern California.

WELDED HOSPITAL BUILDING

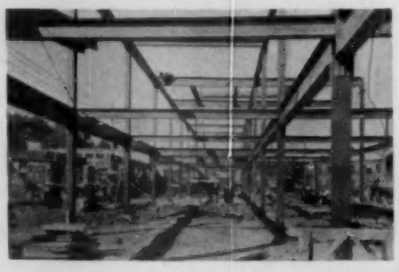
The entire steel frame on the new State Cancer Hospital now under construction in Buffalo, N. Y., is being welded by the Universal Metal Welding Co. of that city who specialize in structural welding of all types and are well equipped to do welding regardless of place having ten portable gasoline driven welding machines.



The welding on this building which is approximately 148 feet x 105 feet five stories high is almost completed and has taken about fourteen days with five portable welding machines welding continuously eight hours per day. Mr. J. H. Mason was superintendent of the welding on this job. There was approximately 1150 lb. of welding electrodes used on this job and all welding was inspected by the Pittsburgh Testing Laboratory of Buffalo.

COMPLETE STEEL WORK ON SCHENECTADY'S EIGHTH WELDED BUILDING

The steel framework for the New York Power & Light Company building, Schenectady, N. Y., has been completed and brick work has been started. This structure marks the eighth building in Schenectady to have an all-welded steel frame. The seventh building, an addition to the Ellis Hospital, is rapidly nearing completion. A new state armory, likewise of welded-steel construction, was finished earlier this year.



Welding operations on the New York Power & Light building were carried on by Clauson Iron Co., Inc., Albany, N. Y.

CRANE COMPANY LABORATORY

Research work which goes on behind the scenes in the plant of a large manufacturer of valves, fittings, plumbing and heating equipment and pumps was revealed at an Open House held by Crane Co., at its Chicago Works in the middle of November. The occasion was inspired by a notable expansion in the Crane research and engineering program.

Although research work has been a part of the Crane program for half a century it has been continually enlarged in recent years until today it occupies two two-story buildings with a total floor space of 86,000 square feet and a personnel of 285. The staff ranges all the way from experts in metallurgy to specialists in the field of ceramics—a body of engineers spending their entire time in the work of controlling the quality of present products and looking ahead to their improvement.

The importance of welding today in the use of valves, fittings and pipe is reflected in the attention paid to welding research in the Crane laboratories. The constant introduction of new alloys with the required changes in welding technique stimulates a great deal of the work in welding research.

A 400,000 volt X-ray enables Crane research workers to examine metals to a maximum depth of ten inches although for practical purposes five inches is about as far as the instrument will penetrate.

WHEN A LIFE HANGS IN THE BALANCE

All possible precautions against loss of life were observed at the National Air Races, Cleveland, August 3rd to 5th. Equipped for emergencies in the event of a sudden crack-up, this operator stands beside his "rescue truck" which holds cylinders of oxygen and acetylene and a

hoist. The operator, protected by his asbestos suit, is ready to advance into the intense heat of a burning ship and cut through the wreckage with his oxy-acetylene cutting blowpipe to free any trapped aviator. Fortunately there was no cause to use this outfit during the meet.

ACCOMPLISHMENTS OF THE RESISTANCE WELDER MANUFACTURERS' ASSOCIATION

Standard Transformer Specifications have been approved and adopted, effective October 1st.

A Standard Cost Estimating Formula has been approved and adopted effective as of October 1st.

Standard Specifications for Spot Welders; Light, Medium and Heavy Duty Press Welders; and Seam Welders have been approved and should result in substantial savings to all Members. Specifications for Flash Welders are now being developed.

Standard Proposal Forms have been approved with the understanding that they will be used as quickly as possible by Members and be generally adopted by every one not later than January 1, 1939.

Standard Cash Discount Terms of 1%, 10 days, net 30 have been approved with the further understanding that on single orders for repair parts totaling less than $100 the terms are to be 30 days net, but if such invoices exceed $100, the regular cash discount of 1%, 10 days, net thirty days shall apply.

An official Emblem has been adopted and all Members furnished with cuts and stickers.

Sales statistics are being compiled on a monthly basis. As a result, Members have accurate information regarding the current trend of business.

A fine spirit of cooperation has been developed among Members of the Association. They have become much better acquainted with each other and are learning to work constructively together for the advancement of their common welfare as well as the best interests of the industry.

All of the above has been accomplished within the Association's budget, all of our expenses being paid.

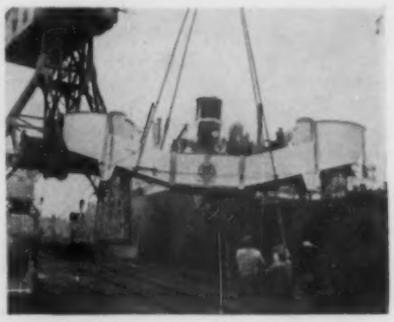
ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

This organization is a conference of engineering bodies organized to enhance the professional status of the engineer through the cooperative support of those national organizations directly representing the professional, technical, educational and legislative phases of an engineer's life.

The Sixth Annual Report now available covers the numerous activities of this body. Copies may be obtained by writing to the Council at 29 West 39th Street, New York.

HUGE PARTS OF 200-INCH TELESCOPE STRUCTURE BEGIN JOURNEY TO MT. PALOMAR

The first large parts for the mounting of California Institute of Technology's giant 200-inch telescope have started their 5000 mile journey by rail, water and tractor-trailer to Mt. Palomar, California. This 200,000 pound shipment included the south end cross member, bearing box girder and smaller sections of the telescope structure.



The 90,000 Pound South End Cross Member of the 200-Inch Telescope Soon to Be Erected at Mt. Palomar, California

These parts, which have been completed in the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company, were taken from the plant by rail to Eddystone and there loaded aboard the freighter "American Robin" of the McCormick Steamship Company.

The South end cross member is the largest and heaviest single unit of the telescope structure. As big as a freight car it is 46 feet long, 10 feet wide, 12 feet high and weighs 90,000 pounds. It forms the south section of the yoke that will support the huge mirror tube and will rotate on the Polar Axis of the telescope.

From Philadelphia the parts will go southward, through the Panama Canal, and around the coast to San Diego. They will be unloaded there on big trailers hauled by tractors, and will be carried 60 miles to the top of Mt. Palomar, partly on the graveled and oiled road built up the mountain by the County of San Diego. This road is thirty feet wide, with 100-foot curves, and is designed to permit automobiles to make the top of the mountain in high gear.

The remaining parts of the mounting, including the telescope tube, rings, cage and horseshoe bearing will follow the same route in two separate shipments handled by the Weyerhauser Steamship Company and the American Hawaiian Steamship Company. Shipping schedules from Philadelphia have been arranged so that the various pieces will arrive in California in the proper sequence required by construction work at Mt. Palomar.

The telescope, which will probably be in operation in 1940, provides for five different optical systems. Observers may photograph the heavenly bodies at the Prime Focus, at the Cassegrain Focus, at the Coudé Focus in the arm of the yoke, or at either the three mirror or the five mirror Coudé which carries the light through the Polar Axis and into an air conditioned chamber beneath the floor at the south end of the telescope.

CLEANING GOGGLES

With constant usage, safety goggles will get dirty, just like any other article of wearing apparel. To protect those workmen whose skins may become irritated or infected by dirt or other foreign matter, American Optical Company suggests the goggles be thoroughly cleaned or sterilized at stated intervals. They recommend the following methods:

1. Wash the goggles in a hot solution of soap and water. Scrub the eyecups, lens rings and side screens with a stiff brush. If the goggles are spotted with paint or tar a ten minute soaking in a solution of varsol will clean the surfaces. Next, soak the goggles for thirty minutes in a 3 per cent cresol solution. Then they should be hung on a support to dry.

2. Wash the goggles in a hot solution of alcoholic green soap, rinse in warm water and hang to dry.

3. Simply immersing the goggles in boiling water for five minutes has been found to accomplish sterilization satisfactorily.

4. Soaking for ten minutes in a solution of formalin made by placing one part of 40 per cent formaldehyde solution in nine parts of water is another simple and practical method.

5. Scour the goggles to remove all dirt and then submit them to a five minute exposure of ultra-violet light. This is usually done in the first aid room or emergency hospital of the company where equipment for doing it is maintained.

6. Another method is subjection to sterilization by a moist atmosphere of antiseptic gas, preferably formaldehyde, for a period of ten minutes at room temperature.

WELDED WINDOWS

Reported to be the largest single order for windows in the history of residential construction, the contract for 65,800

Automatic Welding Machine at the Moment of Welding the Corner of a Fenestra "Swing Leaf" or "Ventilator"

Fenestra bonderized steel windows and steel casings, to be installed in the $50,000,000 community housing project of the Metropolitan Life Insurance Co., located in the Bronx, New York City, has been awarded to Detroit Steel Products Co.

MODERN DUMP SCOWS SPEED UP DREDGING IN CONNEAUT HARBOR

For many years it has been the dream of Great Lakes ship operators to add four feet to the draft of their big coal and ore vessels and thereby increase their tonnage capacities. Millions of dollars are now being spent to deepen the "down channel" and the harbors of the "down ports" from Lake Superior to Lake Ontario, which will make it possible for ship operators to convert the old dream into reality.

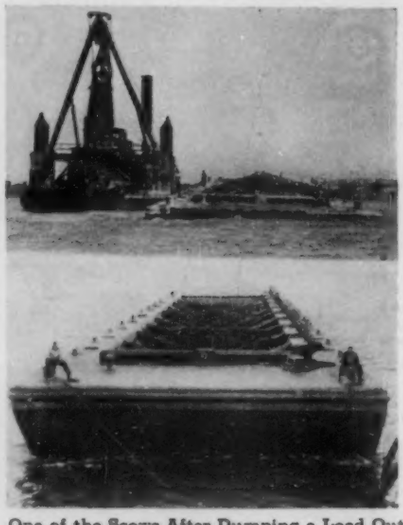
On the "up" trip westward to Lake Superior, the lake freighters carry coal to various ports along the way, and then return on the "down" trip with iron ore which is unloaded largely in Lake Erie ports. Due to the difference in specific gravities, a vessel with a full load of coal draws less water than when fully loaded with ore. For this reason, it is necessary to deepen only the down channels and harbors in order to float larger ships, increasing the draft from the present 20 feet to 24 feet.

The work has been moving forward at a rapid pace, and digging will be completed soon at several Lake Erie ports, among which is Conneaut, Ohio. Dredging at this harbor illustrates the method of operation and involves the use of two 1200 cubic yard capacity all-welded steel dump scows recently built by Dravo Corporation, Pittsburgh, Pa., for the contracting firm, Merritt-Chapman & Scott Corporation of New York.

The scows, which were built to facilitate the race against time and provide substantial savings in operation, are of unusual size and design, being among the largest ever built in an inland waterways shipyard. They measure 206 feet by 40 feet by 14 feet, and required 650 tons of steel for each vessel. Original plans stipulated riveted construction but the increased efficiency in use and the decrease in over-all weight, as well as the construction cost savings, indicated by Dravo's experience with welded construction, led to a change of plans.

Each scow contains nine hopper pockets, each pocket being equipped with two hopper doors constructed of heavy oak timber and steel. The hopper doors are operated by a steam engine connected to a ratchet arrangement on the steel jack

The Dipper Dredge Is Filling One of the Dravo Built Dump Scows. Loading Proceeds from One End to the Other



One of the Scows After Dumping a Load Out in the Lake

shaft, permitting independent opening and closing of the hopper gates. The entire load may be dumped completely within a few minutes. When fully loaded, the scows draw about 12 feet six inches.

After a 2300 mile tow from Pittsburgh, via the Mississippi River, Illinois Waterway and Lakes Michigan, Huron and Erie, the scows arrived at Conneaut on June 9th. Since that time, more than 1,200,000 "scow yards" of harbor bed have been dug, towed six miles into the lake and dumped. A 600 hp. tug, the "Richard Fitzgerald," is used for towing, and the 12 mile round trip is made in $2^1/_2$ hours. On the average, six scow loads are dumped every 24 hours.

Dredging is done with a dipper dredge equipped with a nine cubic yard bucket,

and operated by an eight man crew. A drill boat, drilling and placing blast charges, operates during one eight hour shift per day. Altogether, about 80 men are steadily employed on the project under the supervision of R. E. Mothersbaugh who is in charge of operations at this location for the Merritt-Chapman & Scott Corporation.

ARC-WELDED STAINLESS STEEL THE NEW NOTE IN MODERN SCULPTURE

Sculpturing—one of the oldest media of artistic expression—has manifest itself in many forms and in a variety of materials The carving of figures and images out of wood, chiseling them from stone, molding and modeling them of clay, casting them of metal—these forms of sculpturing have given the world remarkable statuary, enduring memorials and countless adornments and decorations in ornamental work.

Fig. 1—Arc-Welded Stainless Steel Statue of Dr. Sun Yat Sen, China's First President and Most Famous Statesman

Today, a new form of sculpturing and a new material, fashioned in a new way, sounds the modern note in an art which is centuries old.

This new form of sculpturing utilizes the most modern of materials—stainless steel—and a new means of fusing this metal into form and shape—arc-welding. This modern sculptor's tool turns cold steel molten at a touch and fuses it together in a bond as strong as the metal itself. It leaves smooth surfaces, permits even contours, thus allowing the sculptor free rein to his art.

One of the leaders in modern sculpture by the arc welding method is Benjamino Bufano of San Francisco who has produced or has under production nearly a dozen statues of stainless steel arc welded. Examples of Mr. Bufano's work are shown in accompanying illustrations.

Fig. 3—At Left Is Sculptor Bufano Standing Beside the Head of the Saint Francis Statue. The Head Was Pounded Out of Copper in Two Pieces Which Were Arc Welded Together

The monument to Dr. Sun Yat Se famous Chinese statesman and China's first president (see Fig. 1), is Mr. Bufano's best known stainless steel statue. This statue was recently presented to the City of San Francisco by the local Kuomintag, a Chinese organization which financed the work. Acclaimed by critics as a distinguished work of art, it now stands in St. Anne's Square of San Francisco's Chinatown. The sculptor fashioned the parts mainly with wooden tools, then joined them by welding. The figure of the famous Chinese statesman is made of stainless chromium-nickel steel.

Mr. Bufano is now working on a welded steel statue of Saint Francis of Assissi, which will rise to a height of 156 feet—5 feet higher than the figure of the Statue of Liberty, from base to torch. When completed, the Saint Francis statue will stand on Christmas Tree Point, just north of Twin Peaks, near San Francisco.

As a preliminary project in connection with the gigantic Saint Francis statue, the sculptor has just completed a model in stainless steel of the upper section of the statue (see Fig. 2), using arc welding to fuse the stainless steel into one solid piece. The model of Saint Francis' head (see Fig. 3), to be used in making studies for the finished statute, was hammered out of two pieces of copper which were then welded into one piece. Six specially designed stakes attached to a metal horse are used to pound the metal into shapes of nose, cheek, chin and other features.

After the completion of his statue of Saint Francis, Mr. Bufano will begin work on a stainless steel statue of "Peace," a female figure which stands with eyes shut (see Fig. 4). This statue will stand 25 feet in height and will be mirrored in the lagoon at the Golden Gate International Exposition in 1939.

Fig. 2—Sculptor Benjamino Bufano Left, at Work in His San Francisco Studio Making an Arc-Welded Stainless Steel Model of His Saint Francis of Assissi

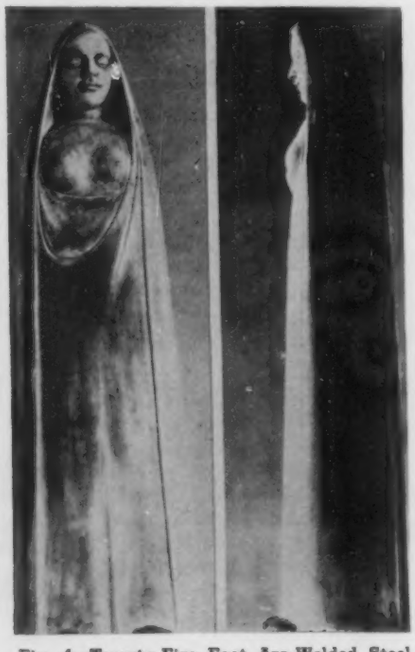


Fig. 4—Twenty-Five Foot Arc-Welded Steel Statue, "Peace" in Profile

Photos courtesy of The Lincoln Electric Company, Cleveland, Ohio.

HAROLD S. CARD

Harold S. Card, who for the past two years has been engaged as director of a business development program for the N. E. M. A. Electric Welding Section announces the inauguration of a sales and advertising consulting service for manufacturers of welding equipment and materials and welding service. The service offered is applicable to both display and direct advertising as well as general sales promotional activities. Mr. Card's new address is Room 517, 30 Church St., New York City.

RULES FOR FUSION WELDING STEAM, OIL OR AIR PIPING IN MARINE CONSTRUCTION

The Board of Directors of the AMERICAN WELDING SOCIETY at its meeting on October 21st voted to adopt as final the Rules published on this subject as appearing in the April 1938 issue of THE WELDING JOURNAL. Minor revisions have been made. The Rules are available in pamphlet form at a nominal charge of 25¢ each.

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

NEW ALTERNARC

New Alternarc machine, type W, 1939 model, compensates current and voltage for constant heat. Latest development by the Electric Arc Cutting & Welding Company, Newark, N. J.

Machine gives uninterrupted infinite variation of both current and voltage with the proper voltage supplied for each current automatically. This is accomplished by sliding a portion of the core of the transformer welder in and out so as to divert the flux from the teaser or control coil. Low voltage is provided for heavy current and high voltage for light current and automatically the current and voltage changes for every interpolation between the extremes of the range. This means a saving in power demand. With automatic machines the voltage is fixed. Heavy current increases the power in direct ratio to the amount used.

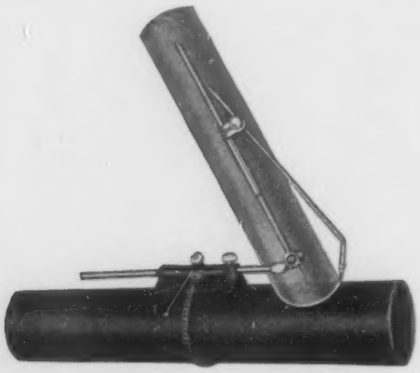
TWINWELD WELDING HOSE

This new contribution to welding, employed to convey oxygen and acetylene for welding and cutting work consists of two lines of unusually flexible, cord-reinforced welding hose, formed by a 22-foot multiple-cavity mold at a temperature of 290° into a single unit. It is stated that the new hose won't kink and taping is not needed. The new hose will not writhe and twist under high pressure. Any differential of pressure in one line has no effect on its companion line. Hewitt Rubber Corporation, Buffalo, New York.

A NEW PIPE-SCRIBER

This Pipe-Scriber is designed to assist welders in easily, quickly and accurately making layouts for practically all pipe joints. The layouts can be made directly on the pipe or for patterns if desired. The Pipe-Scriber can be used on all pipe sizes ranging from 2 inches to 12 inches in diameter.

The introduction of this mechanical Pipe-Scriber eliminates the old "cut and try" method. A 6-way adjustment permits an accurate layout for every conceivable angle and joint. Developed by The Harris Calorific Company of Cleveland.



OUTFIT FOR BODY SOLDERING

A Prest-O-Lite air-acetylene soldering outfit, developed primarily for automobile body work and designed for use with welding size acetylene cylinders or small medium-pressure acetylene generators, has recently been announced by The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation.

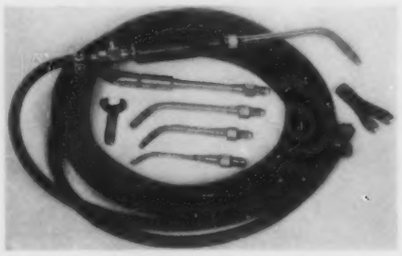


Fig. 1—This New Prest-O-Lite Body Soldering Outfit Connects to Welding Size Regulators and Generators

This outfit will be useful for a remarkably wide range of body soldering operations. It includes four different size stems for fine, light, medium and heavy soldering, and for brazing and heating. Also included is an enclosed-flame soldering copper for work in confined spaces where an open flame might damage adjacent materials.

A NEW SEAM TESTING SERVICE FOR LOCATING LEAKS IN TANK BOTTOMS AND DECKS

A newly developed, accurate seam testing service has just been inaugurated by the American Pipe & Steel Corporation. It is a vacuum method that can be adapted to locating leaks in the bottoms and decks of tanks; ships decks and hulls; pipe lines; and involves a minimum of time and expense, as compared to methods of a more complex and less effective nature.

The patented device used in the American Seam Testing Service is an air-tight, rectangular-shaped box, equipped with a vacuum gage. The top of the box is covered with glass and soft rubber strips are mounted around the base.

When tests are to be made, a section of the seam is covered with a thick solution of soap suds. The device is placed over the covered area and a strong vacuum is created by means of a suction pump. The tremendous suction compresses the soft rubber base of the device so that air is sealed out. Any imperfections in the seam within the area covered by the tester will permit the inflow of air, which in turn will cause large clusters of soap bubbles to appear at that particular point. Detected through the glass top of the seam tester, these bubbles instantly indicate the presence of a leak, no matter how small it may be.

ELECTRODE FOR CAST IRON

Description.—A heavily coated shielded arc electrode designed for depositing a soft machineable alloy on cast iron made by The Lincoln Electric Co., Cleveland, Ohio.

Uses.—For correcting machining errors, filling up defects, for producing a very soft machineable drillable weld, in grey cast iron.

Size.—$^{5}/_{32}$ inch x 16 inch—Polished at end.

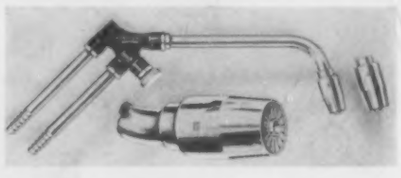
General Characteristics and Instructions.—The coating on this wire (a non-ferrous alloy) is designed so as to cause the weld to flow over and bond to the cast iron with a minimum of penetration or heating of the base metal

Softweld operates best with D.C. negative polarity, although A.C. may be used.

While a single layer deposit will be machineable in the weld metal, at least two layers should be deposited in order to obtain a soft fusion zone. The entire weld area may then be machined, sawed, drilled and tapped without any difficulty.

BLOWPIPE WITH RADIAL GRID TIP

Manufactured by The S. S. White Dental Mfg. Co., Industrial Division, 10 East 40th St., New York, N. Y. The illustration shows the S. S. White No. 8 Blowpipe, a high intensity gas and air torch for general purpose soldering, brazing, etc. It is an extremely well made torch and has a number of novel features which give it a high efficiency and make it easy and comfortable to use.



S. S. White No. 8 Blowpipe and Close-Up of the Radial Grid Tip

OXYACETYLENE CUTTING ATTACHMENT

A new oxyacetylene cutting attachment has been developed by The Linde Air Products Company, Unit of Union Carbide and Carbon Corporation, which will

Fig. 1—Superior Flashback Resistance Is an Important Feature of the Oxweld Type CW-23 Cutting Attachment

be useful for shops where the amount of cutting does not justify the purchase of a separate cutting blowpipe, and for those operations in the field where incidental cutting is to be done or where a minimum of equipment is desired.

The new Oxweld (Type CW-23) Cutting Attachment will cut any thickness of steel up to 8 inches.

WELDERS WITH SELF-INDICATING CONTROL

A line of "Shield-Arc" welders, said to provide greater convenience and accuracy because of a new self-indicating dual continuous control, is announced by The Lincoln Electric Company, Cleveland, Ohio.

These welders have both job selector and current control calibrated and equipped with dials which indicate the type of work and the number of amperes for each and every setting. It is claimed that this development enables the welding operator to secure highest quality welds and highest possible welding speeds because he can vary both the slope of the volt-ampere curve and the amount of welding current independently and positively to suit every job encountered.

Another feature of this welder control is that both voltage control (job selector) and current control are continuous in operation. It is claimed that this simplifies the setting of the control and accounts for an exceptionally wide welding range as to types of work, welding conditions, sizes of electrodes and thicknesses of material.

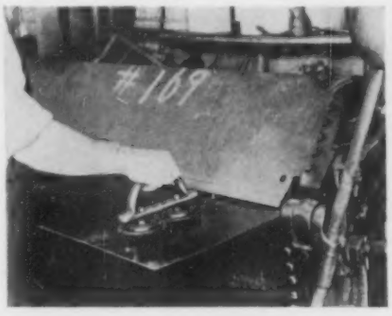
WELDING VALVE

This new foot control valve, adaptable to various types of equipment, is especially suited to the operation of Seam Welders where cylinder action, as used for clamping or holding, must be followed through with a push button action for delivery of electric current to create the actual weld.

The desired results can now be accomplished with one compact unit, through the use of a built-in limit switch which is actuated after the foot treadle has gone through the major portion of its stroke. Ross Operating Valve Company, 6488 Epworth Boulevard, Detroit, Michigan.

EVEREADY LIFTERS

Illustrated in use is one of 5 models of "Eveready Lifters" which are being placed on the market by The Bastian-Blessing Company, 242 E. Ontario St., Chicago, Illinois. These units provide the answer for manufacturers who are seeking a faster and safer method of handling sheet metals, sheet glass, in fact any product that has a smooth, non-porous surface.



These lifters are of patented design, incorporating giant rubber vacuum cups which are provided with automatic releases that work with the flick of a finger.

HARD-FACING FOLDER REVISED

An extensively revised folder, "Hard-Facing with Haynes Stellite Rod (Oxy-acetylene Process)," has just been completed by Haynes Stellite Company, a Unit of Union Carbide and Carbon Corporation. The revised folder presents the complete procedure for hard-facing steel wearing surfaces by the oxyacetylene process. The procedure is condensed so that it can readily be followed by a welding operator, even when he is actually hard-facing a part. In addition, the publication contains all necessary data on the different grades of Haynes Stellite hard-facing rod.

LINCOLN BULLETIN

Procedures for producing all types of welds in mild steel, for welding all metals used to any extent industrially and for applying surfacing metal to meet any type of wear-action in service, are given in a new bulletin just received from The Lincoln Electric Company, Cleveland, Ohio.

Of value to all users of welding, the bulletin is available on request from The Lincoln Electric Company, Cleveland, Ohio. In writing for it, ask for "Bulletin 401-A."

BOUND VOLUME WANTED

One of the British members of the Society would like to purchase Volume No. 1 and Volume No. 2 of the bound volumes of the Journal of the Society. Any member desiring to sell these at $5.00 per volume please communicate with the Secretary.

LONGEST ELECTRIC STAIRWAY

The most modern version of the perambulating staircase, to be installed in the World's Fair Theme Building, is rapidly taking shape at the Jersey City Works of the Westinghouse Electric Elevator Company. It will carry floods of visitors directly into the heart of the towering Trylon and the 200-foot Perisphere.

Welding Truss of Electric Stairway for Theme Building of the 1939 New York World's Fair. (Westinghouse Electric Elevator Company, Jersey City, New Jersey)

It will be the longest and highest electric stairway built in the United States, possibly in the world. Leading to the upper platform of the Perisphere, it will be 120 feet long and have a vertical rise of 60 feet. Two feet wide, the shining belt of nickel steel and glossy micarta finished in the orange and buff colors of the Fair, will pour 4000 visitors an hour into the wonderland of the future. Its treads, so constructed that passengers will be riding in absolute safety, will whirl upward at the rate of 90 feet per minute. At the top, it will open directly upon a large revolving platform.

A sister stairway will be built from the entrance to the interior of the Trylon. This electric carrier, also two feet wide and capable of accommodating the same number of people, will be 96 feet long, with a vertical rise of 48 feet.

The total cost of the two moving stairways is over $80,000.

BRAZING BULLETIN

An interesting bulletin has been recently published by Handy and Harman, 82 Fulton Street, New York, N. Y., which gives in detail the right procedure to follow in brazing cemented carbide tool tips to tool holders.

» » » SECTION ACTIVITIES « « «

BIRMINGHAM

The following is the program for the next few months for the Birmingham Section.

November 7th—"Welded Joints—Which Ones to Use and When and Why," Mr. Leon C. Bibber, Welding Engineer of the Carnegie-Illinois Steel Corporation.

November 26th—"Arc-Welded Road Equipment," by Mr. Elmer Isgren, Supt. of the R. G. LeTourneau Company.

December 15th—Mr. A. E. Gibson, President of the Wellman Engineering Company, past-president of the AMERICAN WELDING SOCIETY, will speak, his subject to be announced later.

About January 10th, "Qualification and Procedure Control from the Standpoint of the Contractor," by Mr. F. C. Fantz, President of the Midwest Piping and Supply Company, St. Louis, Mo.

In February—"Welded Piping," by Mr. E. R. Seabloom, Research Engineer of Crane Company, Chicago, Illinois.

BOSTON

The Section Meeting held on December 21st, at the River Works of the General Electric Company, Lynn, was a joint meeting with the Boston Society of Civil Engineers and consisted of an afternoon inspection trip and an evening technical meeting, as indicated by the following program.

Program—Shop visitation during afternoon, 2.30–5.00. Principles of Street Lighting by Miniature demonstration. Because of limited capacity of the display room, the party was divided into groups of not more than 20, scheduled at the following times: 3.00, 3.30, 4.00, 4.30, 8.30 P.M.

Supper—General Electric Cafeteria. Price, 65¢.

Recreational—G.E. Auditorium, 6.00–7.00 P.M.—Motion Picture Comedy, Stereoptican with record—America's Fatal Streets; Motion Picture Film, Making a Pullman Car.

Technical Meeting—7.00–8.30 P.M., G. E. Auditorium.

Speaker: Theodore Whitney, Whitney Engineering Company

Subject: Welding Applications in New Massachusetts General Hospital Building, Boston.

Speaker: C. T. Anderson, General Electric Company

Subject: Welding Application to New Gear Building, River Works.

Speaker: John Milo, General Electric Company

Subject: Heating and Ventilating New Gear Building.

Speaker: A. T. Comstock, General Electric Company

Subject: 1500-Lb. Steam Distribution System.

Principles of Street Lighting, by miniature demonstration, at 8.30 P.M.

IMPORTANT: Only U. S. Citizens were admitted to this meeting and inspection trip.

The subject of pipe welding was considered at the November 21st meeting when the following program was presented:

Speaker: Lewis P. Gove, Engineer, Mutual Boiler Insurance Co.

Subject: "Pipe Welding at the L Street Station of the Boston Edison Company."

Speaker: Roger Clark, General Electric Company, Schenectady

Subject: "Welded Joints in Carbon Molybdenum Piping."

The meeting was held in Room 4-270, Mass. Institute of Technology, at 8 P.M. Lantern slides were used.

The new addition to the Massachusetts General Hospital to be known as the Robert White Memorial Building is in process of erection. About 2400 tons of steel will be used in the framework and is being fabricated by arc welding. This building will be about 200 feet high.

CHATTANOOGA

The Chattanooga Section held its monthly meeting Tuesday evening, December 13th, with approximately 75 present.

Mr. A. E. Gibson, president, Wellman Engineering Company, Cleveland, Ohio, gave a very interesting talk on "The Welding of Heavy Mechanical Equipment, with Particular Stress on Design and Welding Appliance and Their Effect on Cost." His talk was well illustrated with lantern slides.

The Chattanooga Section held a meeting on November 29th, with approximately 65 present. The speaker was Mr. A. J. Raymo, Welding Engineer of the Philadelphia Navy Yard. He gave a very interesting talk on "Control of Distortion in Welding Fabrication."

At its regular meeting held November 9th, with seventy-five present, new officers were installed for the coming year as follows:

Chairman—Chester Raymo
Vice-Chairman—Mark Holt
Secretary-Treasurer—A. R. McLain
Executive Committee, A. J. Moses, C. E. Kimball, J. E. Morelock, B. L. Sylar, T. R. Williams and R. B. Bayston
Program Chairman—Robert Daniels
Chairman, Membership Committee—B. L. Sylar
Chairman, Educational Committee—E. T. Welch
In charge of Publicity—Mark Holt

The regular meeting date was established as the first Wednesday of each month.

The principal speaker of the evening was Mr. Leon C. Bibber, Welding Engineer for Carnegie-Illinois Steel Corp. He presented a very interesting talk on the subject "Welded Joints—Which Ones to Use and When and Why." A film "Cor-Ten Steel" was also shown.

CHICAGO

The regular monthly meeting of the Chicago Section was held on December 16th at the Chicago Lighting Institute. Mr. J. F. Lincoln of The Lincoln Electric Company, presented an instructive address on "Welding and Profit *vs.* Price and Prejudice." A special added attraction was the presentation of an illustrated talk on the identification of wire, fired bullets and the use of the polygraph—"Lie Detector," by Charles M. Wilson.

Friday evening, November 18th was National President's Night. Mr. H. C. Boardman, Research Engineer of the Chicago Bridge & Iron Co., and newly elected President of the Society, in whose honor the night was planned, was the speaker of the evening. His subject was "Welded Steel Spheres, Spheroids and Elevated Tanks."

A Get-Together Dinner preceded each of these meetings in The Electric Club.

The special added attraction was Clare Bryan, World Champion trick bait caster who presented a spectacular exhibition of accuracy casting, using a young lady as a living target.

COLUMBUS

At the last regular meeting at the University there was a round table discussion on different types of welding, which was very enlightening and instructive, especially for the younger members of the Society. The meeting was very well attended, and there were a number of visitors present from the various industries in Columbus and neighboring towns.

The next regular meeting on January 13th will be a dinner meeting at 6:30. Mr. Slottman will be present to speak on "Flame Heating and Hardening."

DETROIT

The December meeting held on the 16th at the Detroit Leland Hotel was addressed by Dr. F. R. Hensel, Consulting Engineer for P. R. Mallory & Company, Inc., Indianapolis, Ind., whose subject was "Data on Spot Welding of Stainless Steel to Yellow Brass."

The November meeting held on the 10th at the Detroit Leland Hotel was well attended and proved to be very interest-

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ing. Mr. H. C. Boardman of the Chicago Bridge & Iron Company, presented an illustrated talk on "Large Welded Tanks of Cylindrical, Spherical and Spheroidal Shapes."

KANSAS CITY

The Kansas City Section had a most enjoyable evening at the November 14th meeting. Mr. J. J. Vreeland, Metallurgical Engineer of the Chase Brass and Copper Co. Inc., gave an illustrated talk on "Carbon Arc Welding of Copper Base Alloys."

On December 12th, Mr. J. H. Deppeler, Chief Engineer and Works Manager of the Metal and Thermit Corporation, addressed the gathering on "Welding Electrodes and Their Uses." In addition to this subject, Mr. Deppeler gave some very interesting information on Thermit Welding. His talk was illustrated with slides and was much enjoyed by the 75 members who attended.

On January 9th, Mr. J. F. Lincoln, President of The Lincoln Electric Company, will address a special meeting. This will be a joint meeting of all the engineering societies and will be sponsored by the Kansas City Section. The meeting is to be held in Edison Hall at the Power and Light Building.

MARYLAND

On November 18th the first meeting of the season was held by the Maryland Section. The speaker was Dr. Slottman of the Air Reduction Sales Company. Dr. Slottman gave a very interesting talk on Gases used in Welding and Cutting, and also covered the action of the gases through the tips, explaining these actions with slides. The talk proved most instructive to all present. Visitors and members present were 60. There was quite a lengthy discussion after the meeting.

MILWAUKEE

The regular monthly meeting of the Milwaukee Section was held in the City Club of Milwaukee and was preceded by a dinner. Mr. E. J. Galbos, District Traffic Manager, United Air Lines, gave an afterdinner talk on "Coast to Coast by Plane." Mr. L. B. Olsen and Robert King, Welding Supervisors of the Manitowoc Ship Building Company, presented an illustrated talk on "Cutting and Welding in Ship Construction."

The January meeting to be held on the 27th is to be National President Night. President Harry Boardman will be the guest speaker.

Mr. C. H. Jennings, Research Engineer of the Westinghouse Electric and Mfg. Co., presented an illustrated lecture on "Welding Practices in Europe and America" at the November 30th meeting.

The Chicago Section extended an invitation to the Milwaukee Section to attend a special meeting in honor of Mr. Harry Boardman, newly elected President of the AMERICAN WELDING SOCIETY, which meeting was held on November 18th in Chicago.

Mr. E. J. DeWitt, Vice-President of Wallace Supplies Mfg. Co. spoke on "Welding, Cutting and Machine Design of Small Sub-Assemblies" at the October 28th meeting of the Section.

MONTANA

The third technical meeting of the 1938-39 Winter Season program of the Montana Section was held November 2, 1938. The first paper of the evening was entitled, "Welding in the Mining Industry," by Mr. Wm. Galloway, Vice-Chairman of the Montana Section. This paper was of extreme interest because of the diversified mining activities carried on within the state of Montana. The second paper, "Distortions and Failures Due to Welding," by Mr. Harry Griffith of the U. S. Engineer Department. In the discussion which followed many of those present related their experiences in distortions and failures which resulted from Welding. This accumulation of experiences resulted in a very enlightening meeting.

Two papers also made up the program of the December meeting of the Montana Section which was held on December 7th. The papers were related and pertained to the crater formation in electric arc welding. The first paper, "Crater Formation," was presented by Mr. Peter J. Carpani, while the second, "Some Theories on Crater Formation," by T. B. Jefferson. Messrs. Carpani and Jefferson are associated with the U. S. Engineer Department at Fort Peck, Montana, in the capacity of Welder and Engineer-in-Charge of Shops, respectively.

Both papers brought out many interesting facts. The mysteries that are connected with the formation of craters in arc welding provoked a spirited discussion following the presentation of these papers.

The annual anniversary meeting of the Montana Section will be held in Glasgow, Montana on January 6, 1939. This will be a dinner meeting. Following the banquet a paper prepared by President Boardman of the AMERICAN WELDING SOCIETY will be presented.

NEW YORK

A Meeting of the New York Section, AMERICAN WELDING SOCIETY was held on Tuesday, December 13, 1938 at 7:30 P.M., in Room 501, Engineering Societies Building, 33 West 39th Street, New York, N. Y. Mr. J. L. Wilson, Assistant Chief Surveyor, American Bureau of Shipping and Chairman of New York Section A.W.S. presided. Mr. Everett Chapman, President, Lukenweld Incorporated, was the speaker and gave a very interesting talk on "Some Problems of Welded Steel Fabrication." Mr. Chapman's address was accompanied by a number of interesting lantern slides. Following his lecture, Mr. Chapman showed a very interesting moving picture on transient heat stresses. The meeting was attended by approximately 700 persons. Advance program of other Meetings scheduled are as follows:

Advance Program of Meetings 1939

Tuesday, Jan. 10, 1939—"Impact Testing of Welded Structures" by Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Corporation.

Tuesday, Feb. 7, 1939—"High Spots in the Welding of Copper Alloys" by Ira T. Hook, Research Engineer, The American Brass Company.

Tuesday, Mar. 7, 1939—"Welded Steel Tankers" by W. P. Jupp, Marine Department, Socony Vacuum Oil Company, "Welding in Ship Construction" by B. A. Russell, Chief of Hull Estimating & Designing Department, Federal Shipbuilding & Dry Dock Company.

Monday, April 10, 1939—"Low Alloy Steels" by A. F. Steubing, Carnegie-Illinois Steel Corp. (Joint Meeting with New York Section, American Society for Metals).

Tuesday, May 9, 1939—Business Meeting and Dinner, World's Fair Grounds.

Subject to Periodical Notice, Meetings Start Promptly at 7:30 P.M.

A Joint Meeting of New York Section, AMERICAN WELDING SOCIETY and Metropolitan Section, American Society of Civil Engineers, was held on Wednesday, November 16, 1938, at 8:00 P.M., in Room 501, Engineering Societies Building, 33 West 39th Street, New York, N. Y. Rear Admiral R. E. Bakenhus, U. S. N. (Retired) presided. Mr. F. H. Frankland, Chief Engineer, American Institute of Steel Construction, Inc. presented a comprehensive paper on "Welding in the Structural Field" and Mr. C. E. Loos, Assistant to Mechanical Engineer, American Bridge Company gave an interesting lecture on "Structural Fabrication by Welding." Both talks were well illustrated by lantern slides. A very good color motion picture film showing the progress of the work on the first all-welded steel frame school building constructed under the Building Code of the City of New York was then shown and discussed by Mr. A. N. Kugler, Mechanical Engineer, Applied Engineering Department, Air Reduction Sales Company. Following the Meeting, refreshments were served in an adjoining room. Approximately 600 persons succeeded in crowding into the lecture hall and about 150 more were unable to gain admittance.

NORTHERN NEW YORK

The regular monthly meeting of the Northern New York Section was held on October 28th, at Rice Hall, Schenectady. Messrs. Kidd and Aldrich of the M. W. Kellogg Co., Jersey City, gave a very interesting talk and movie on the construction and flotation of the large refinery towers from Jersey City to Whiting, Indiana.

The program for the balance of the year is as follows:

Thursday, November 17th: Discussion of important papers presented at Detroit Committee-Dinner Meeting.

Thursday, December 15th, Building No. 32, G. E. Co. Schenectady: Procedure Control in Welding. A Round Table discussion by F. H. Miller & R. W. Clark.

Thursday, January 12th, Rice Hall,

Schenectady: The Velvet Track. Continuously welded mile long rails. Mr. Loos—Sperry Products, Inc.

Thursday, February 23rd, Bldg. No. 32, G. E. Co., Schenectady: Modern Art of Resistance Welding Applied to Fabrication of High Speed Trains and other Types of Vehicles. J. J. MacKinney—Research Engr., E. G. Budd Mfg. Co.

Thursday, March 30th, R. P. I., Troy, N. Y.: Rensselaer Polytechnic Institute, Welding meeting—Dinner meeting.

Thursday, April 27th, Bldg. No. 32, G. E. Co., Schenectady: Welding of Unfired Pressure Vessels, American Locomotive Co.

Thursday, May 25th: Annual Dinner Meeting.

NORTHWEST

This Section was indeed fortunate to have Harry C. Boardman, President of the AMERICAN WELDING SOCIETY, as its guest speaker December 14th. The meeting was held at the Minnesota Union, University of Minnesota. Mr. Boardman discussed "Welding Research by Practical Welders" and "Qualification Tests" in a most interesting way, and all those present received a great deal of benefit.

The Section's Educational Committee has decided to hold a brief period after each Section meeting for answering questions which the various members have handed in at a previous one. At every meeting cards will be distributed on which the members and visitors will be asked to submit questions of a practical nature, which they would like to have answered. These cards will be turned over to the Committee, which will submit them to some of the members who are best qualified to supply the answers, and a verbal or written report will be made at the succeeding meeting.

Because of the increasing interest in welding in this territory, the University of Minnesota is planning an engineering course on welding to be given in February 1939 at the Center for Continuation Study, and this Section will cooperate with the University authorities in every way to make it a success.

A very interesting meeting was held on November 16th at the Minnesota Union, University of Minnesota, when G. O. Hoglund, Welding Engineer, Aluminum Company of America, spoke on "Welding Aluminum and Its Alloys." Approximately 100 members and guests attended all of whom were very much impressed with Mr. Hoglund's discussion of his subject.

Dr. G. V. Slottman, Assistant Manager, Applied Engineering Department, Air Reduction Sales Company, presented an illustrated talk and motion pictures on "Flame Hardening."

OKLAHOMA CITY

The Oklahoma City Section held its regular monthly meeting Tuesday evening, November 1st, at the Huckins Hotel

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and a large attendance enjoyed the program.

The speaker of the evening was Mr. E. R. Seabloom, Research Engineer with Crane Company of Chicago, who spoke on the subject of, "The application of Fusion Welding to pressure piping."

Mr. Seabloom spoke "as one having authority" and gave freely of the results of his vast research experience in connection with welded piping for high pressure and high temperature service.

Preceding the address, motion pictures on the same subject were shown through the courtesy of the Bastian-Blessing Company, the title of the picture being "Pipe Welding and Cutting." These films illustrated the economy of welded piping and ease and convenience of installation in large buildings.

Another of the enjoyable dinner meetings was held by the Oklahoma City Section in the Huckins Hotel, Tuesday evening, December 6th, at which time about thirty-five members and guests enjoyed a roast turkey dinner served with all the trimmings, seasoned with sociability and garnished with good fellowship.

This meeting received some advance newspaper publicity in that it was called "Our President Meeting" in view of the fact that Mr. H. C. Boardman, our National President, was the guest and principal speaker.

Mr. Boardman spoke on the subject, "A. W. S. Qualification Rules and Welding Research" and illustrated his talk with slides describing some typical joints used in the construction of field welded storage

tanks and also slides covering the proposed types of qualification tests.

A feature of the evening was the presentation of a gavel to Mr. Boardman. A silver plate was attached to the gavel and suitably engraved with the society emblem, name of the section, the date and, of course, the name of Mr. Boardman.

PEORIA

Mr. James F. Lincoln, President of The Lincoln Electric Company, addressed the December 15th meeting of the Peoria Section on "Welding *vs.* Prejudice." Mr. Lincoln's talk was illustrated with slides.

Mr. Edward J. DeWitt, Vice-President of the Wallace Supplies Mfg. Co., was the speaker at the November 2nd meeting. His topic was "Welding, Cutting and Machine Design of Small Sub-Assemblies." The attendance at the meeting was very good and the interest shown very satisfactory.

PHILADELPHIA

A very interesting meeting of the Philadelphia Section was held on November 21st. Mr. A. J. Moses of the Hedges-Walsh-Weidner Division of Combustion Engineering Company, Inc., presented a paper on "Welding and Design of Stainless Steels." After the presentation of the paper, there was a discussion which was entered into by a number of those present.

The following is the program up to May 1939.

January 16, 1939—"New Applications of Gas Welding."

February 20, 1939—"Residual Stresses."

March 20, 1939—"Structural Design and Welding."

April 17, 1939—"Steel Casting and Plate Fabrication." (Joint Meeting with American Foundrymen's Association.)

May 1939—Annual Inspection Trip.

The above meetings will be held at the Engineers' Club at 8:00 P.M.

PITTSBURGH

The next regular meeting of the Pittsburgh Section will be held in the Mellon Institute of Industrial Research, Wednesday night, January 18th at which time Mr. F. C. Fantz, Vice-President of the Midwest Piping and Supply Company, Inc., St. Louis, Missouri, will speak on the subject of "Welded Piping."

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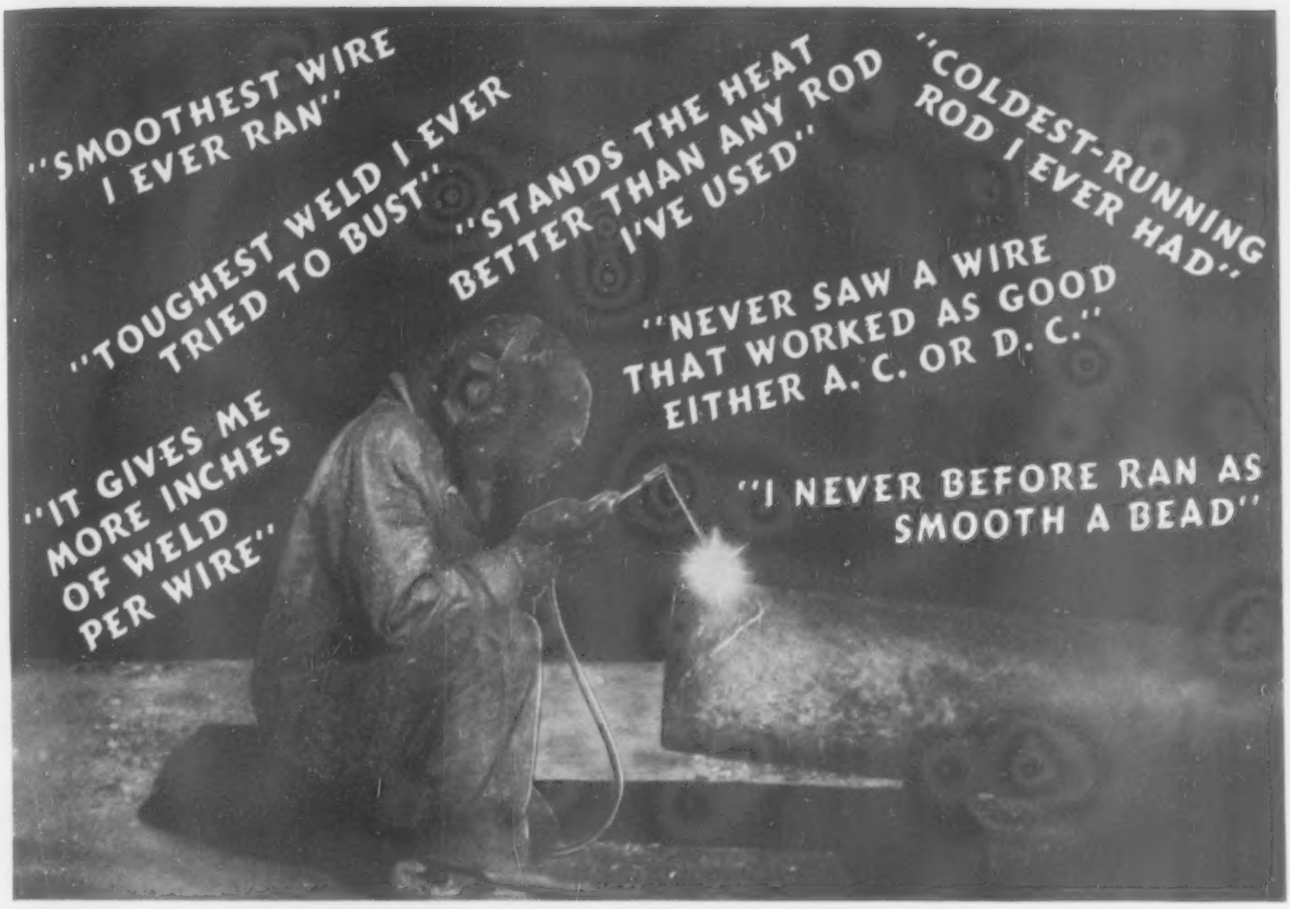
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sizes Mr. Fantz is particularly well fitted to speak on the subject.

Both the design and technique for welding high pressure piping will be discussed. The talk will be illustrated with slides showing large high pressure pipe assemblies both in the shop and field.

An attendance of over one hundred heard Col. G. F. Jenks, Ordnance Department, U. S. Army, speak on the "Application of Welding to Ordnance," in the Mellon Institute of Industrial Research, Wednesday night, November 16th.

Col. Jenks used a large number of slides in connection with his discussion and provided one of the most interesting meetings held by the Pittsburgh Section.

Following his talk the meeting was thrown open to general discussion and it was evident from the type and number of questions asked that the attendance was made up of many persons who were there to get answers to their many problems.

Following the usual custom of the Pittsburgh Section no meeting will be held during December.

ROCHESTER

The January meeting of the Rochester Section was held on the 5th in the Todd Union of the University of Rochester. Mr. Clinton E. Swift of the American Brass Company was the speaker and his subject was on "Welding of Copper and Its Alloys." At the dinner preceding the meeting there was a coffee talk by Mr. Donald P. Masterson, welding instructor at Edison Tech. High School.

The December meeting was held on the 1st in the Todd Union on the River Campus of the University of Rochester. The speaker was Robert T. Gillette of the Works Laboratory of the General Electric Co., whose subject was "Resistance Welding." Mr. Donald P. Masterson gave a coffee talk at the dinner preceding the meeting.

ST. LOUIS

The regular meeting of the St. Louis Section was held on December 9th in the Engineers' Club Auditorium. Mr. Leon C. Bibber, Welding Engineer, Carnegie-Illinois Steel Company, lectured on "Welded Joints—Which Ones to Use, When and Why." Mr. Bibber's lecture was illustrated with a sound movie.

The November meeting held on the 18th in the Engineers' Club Auditorium was addressed by Mr. John J. Vreeland, Metallurgical Engineer, Chase Brass & Copper Co., on the subject "Carbon Arc Welding of Copper Base Alloys," a discussion of recent developments in copper welding and the high strength welding of silicon bronze.

SAN FRANCISCO

A meeting in the nature of a symposium was held by the San Francisco Section on December 20th at the Richmond Refinery of the Standard Oil Company. Dinner at the Carquinez Hotel preceded the meeting. Talks were made by members of the Company personnel. In addition, there was a demonstration of the Company's testing equipment by their metallurgist, Mr. W. J. Jackel. Among the subjects discussed were Training and Qualification of Company Welders, Checking the Design of Welds, Inspection of Welds.

Dr. W. F. Durand, Professor Emeritus, Mechanical Engineering, Stanford University, was the speaker at the November 25th meeting. He spoke on "Subject Matter Pertaining to General Welding."

At the October 21st meeting Mr. Eugene F. Amthor, Construction Engineer, explained the details of the building of the Welded Steel Dump Scows for the U. S. Government.

SAN JOAQUIN VALLEY

Mr. B. Rhinehold, President, Abegg & Rhinehold Company, was the guest speaker at the November 17th meeting of the San Joaquin Valley Section. His subject was one of interest to all present, and his answers to the many questions asked at the close of the paper were most educational in that the many questions asked were all pertinent to the Oil Industry and its problems. A most enthusiastic group turned out to hear Mr. Rhinehold. The films by the Associated Oil Company in the field of sports were thoroughly enjoyed by every one.

At the request of the members of the Section, future meetings will be held on Fridays instead of Thursdays.

In spite of unfavorable weather conditions, some sixty persons attended and enjoyed the program of the meeting on October 27th. Mr. J. E. Jordan, Vice-President, Compton Metal Homes, Inc., presented a paper on "Recent Developments in Design and Construction of Metal Homes;" Mr. Floyd Smith, Plant Foreman, Bakersfield Motor Center, presented his Lincoln Contest paper on "Repair and Reclamation of Automotive Cylinder Blocks by Electric Welding." In addition to these two scheduled papers, there were also presented a very timely and interesting paper on "Multiple Flame Welding of Pipe Lines" by Mr. "Bud" Fisher, Sales representative of The Linde Air Products Company.

SOUTH TEXAS

The Fall meeting of the South Texas Section was held on November 4th. Mr. Orville Barnett of Black, Sivalls & Bryson, Inc., gave an illustrated talk on "Welding, Testing and Inspection of A. P. I.-A. S. M. E. Unfired Pressure Vessels." At the conclusion of Mr. Barnett's talk, a lively discussion followed.

TULSA

At the December 7th meeting of the Tulsa Section, Mr. H. C. Boardman, President, Chicago Bridge & Iron Company and President of AMERICAN WELDING SOCIETY, was the dinner speaker. He spoke on the subject "Large Welded Field Tanks of Cylindrical, Spherical and Spheroidal Shapes." About thirty-five members and guests attended the dinner, with an additional thirty-five after-dinner attendance. All those present enjoyed this most interesting address.

Mr. E. R. Seabloom, in charge of Research for the Crane Company, spoke on "Welding High Pressure Piping," at the November 24th meeting held at the Hotel Alvin. About sixty members and guests were present.

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WESTERN NEW YORK

The Western New York Section held a meeting on November 17th in the Electric Building, Buffalo. The speaker was Mr. H. C. Boardman, President of the Chicago Bridge and Iron Company and of the AMERICAN WELDING SOCIETY. His subject was "Field Welding Tanks" and his talk was illustrated by some very interesting slides. Mr. Boardman gave a very interesting talk and answered numerous questions at the end of his talk. This was one of the best local meetings held by the Section both from the standpoint of attendance and interest created by the speaker. There was an attendance of approximately seventy members and friends.

The first meeting of the current season was held on October 27th. Mr. A. E. Gibson, President of the Wellman Engineering Company and past-president of the Society, spoke on the influence of design details on the cost of welded equipment. His talk was illustrated by slides and it was followed by a long discussion by various members present.

WICHITA

The Wichita Section held its December meeting in the Hostess Room of Wolf's Cafeteria on the 13th. A Dutch Cafeteria Style dinner preceded the meeting. Mr. J. H. Deppeler, Chief Engineer and Works Manager, Metal & Thermit Corporation presented an illustrated talk which was well received.

YOUNGSTOWN

A joint meeting of the Youngstown Section of the A. W. S. and the Mahoning Valley Chapter of the A. S. M. was held on December 6th in the Ohio Edison Auditorium. Dr. J. C. Hodge, Consulting Metallurgist with Babcock & Wilcox Company addressed the meeting on "X-Ray and Magnaflux Testing of Welds." In addition to this address, Dr. Hodge showed motion pictures illustrating the welding problems on Boulder Dam construction.

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A-293. Welder with 7 years experience as welding inspector and 16 years as salesman.

A-294. Three years experience in Oxy-acetylene, general shop and pipe welding. Now training in Arc welding. Can furnish good references. Will go anywhere anytime.

A-295. Research Engineer in Arc Welding desires position either in developing arc-welding electrode coatings or welding procedure and weld testing. Previous work consisted of making chemical and physical tests and analysis on electrode coatings, as well as on the coating ingredients, core wire, weld metal and steels, which work necessitated knowledge of analytical, organic and inorganic chemistry, metallurgy, welding procedure and arc welding. Twenty-seven years old, married.

A-296. Welding Engineer desires position. Age 25. Has practical welding experience in shipyard as welding technician and in charge of work. Acted as an instructor. Has also had laboratory experience. Can handle crew of welders and inspection.

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